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THE  
**COLORADO**  
**BEEBLE**

BY  
CHARLES V. RILEY. M.A. PH.D.



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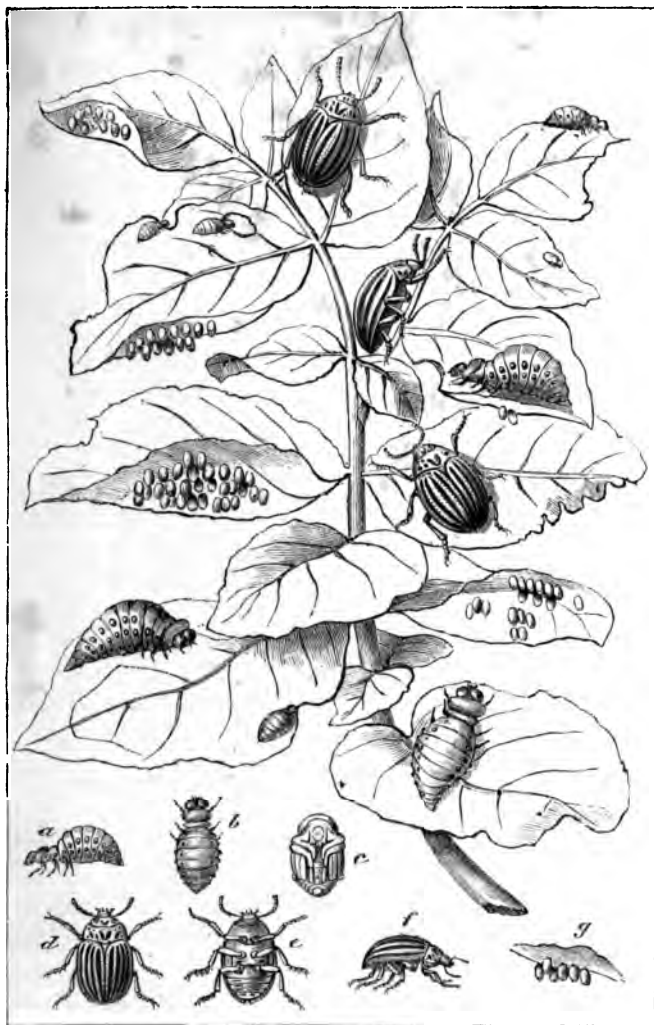
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### THE COLORADO BEETLE.

LARVÆ AND PERFECT INSECTS AT WORK ON THE POTATO-PLANT, THE DIMENSIONS BEING SLIGHTLY ENLARGED.

*The bottom figures show the comparative natural sizes. c, pupa; g, eggs b, side and back views of larva; d, e, f, back, ventral, and side views of the insect.*

THE  
COLORADO BEETLE.

WITH SUGGESTIONS FOR ITS REPRESSION AND METHODS  
OF DESTRUCTION.

BY  
CHARLES V. RILEY, M.A., PH.D.,  
STATE ENTOMOLOGIST OF MISSOURI.

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## PREFACE.

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THE Colorado Potato-beetle, to the consideration of which the following pages are principally devoted, continues to occupy a good deal of public attention; and now that its transportation to Europe has become a demonstrated possibility, demands from Europe for information regarding it are added to those that have been continually made by our own people as the insect has widened the area of its devastations. The editions of the earlier Entomological reports of Missouri have long since been exhausted, and the author has, to his regret, been unable to satisfy, of late years, the many applications for his writings on the subject. To this circumstance, and to the suggestion

of the publishers that he should bring those writings together in some cheap, available form, with brief accounts of the other insects that injuriously affect the potato, this little volume owes its origin. With the explanation that the term "larva," so frequently employed, means the second or worm-like state of an insect; that the term "pupa" means the third or dormant state; and that all statements rest either on his own experience, or on authorities cited in his reports, the author submits this little work in the hope that it may somewhere find a welcome, and to some one prove a source of profit.

C. V. RILEY.

ST. LOUIS, MO.

## INTRODUCTION.

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THE Potato ranks deservedly high among the products of the farm. A luxury even to the rich, it yet forms the poor man's principal article of diet. Easily cultivated ; yielding generously ; thriving in most soils ; requiring no process of manufacture to fit it for use—it is justly esteemed the most valuable of esculents. Whatever, therefore, injuriously affects it, excites general apprehension, and demands careful consideration.

The agencies which, at present, militate most seriously against successful potato-culture are fungus diseases, and noxious insects. It is with the latter that the following pages deal, and more particularly with the Colorado Potato-beetle, which is the most injurious and widespread of them.

Two interesting phenomena invariably accompany the settlement by civilized man of a country previously unoccupied by him : 1st, the exceptional

increase and spread of the few indigenous species which exhibit exceptional powers of adaptation to the changed conditions that such settlement implies ; 2nd, the more general increase and spread of European species, which have, through "natural selection" for centuries, most effectually conformed to those conditions, and which, by virtue of this greater adaptation crowd out the endemic forms. America, Australia, New Zealand, have been overrun by European imports, and are good illustrations in point. The increase and spread of one species necessitates the decrease—often to extermination—of another ; and the adaptation of an endemic species to new conditions, as also the introduction and spread of a foreign one, imply, and have often carried with them, modification in habit and character.

Within seventeen years there has been a grand revolution in the minds of thinking men as to the origin of things upon our earth. The idea of special creation of what we call "species," almost universally held prior to that time, has given way to that of the derivative origin of existing from pre-existing forms. Darwin has revolutionized our ideas, and *given to the study* of life, broader and deeper

meaning than it had before ; and there can be no better evidence of the change in public opinion, in this respect, or of the force of the doctrine of evolution, than the respect with which Huxley was recently listened to in New York, and the failure of opposers to weaken his arguments. The "survival of the fittest" aptly expresses one of the axioms of evolution, and among the most beautiful illustrations of it, and consequently, among the more tangible evidences of evolution which man, in present experience, can have ; must be reckoned the visible changes that occur through his influence in the fauna and flora of a country—and particularly the two classes of phenomena just alluded to. It is, therefore, an interesting fact, that since 1859, the very year when the "Origin of Species" was first given to the world, America has afforded striking illustrations of both. In the Colorado Potato-beetle (*Doryphora 10-lineata*) we have a native species whose eastward spread has been carefully watched and recorded, from year to year ; and in the Rape Butterfly (*Pieris rapæ*) an European species whose introduction and westward advance have been equally well observed since that time. Both have been found in these comparatively few years to

undergo modification in habit and character. The history of the former thus acquires an interest to the naturalist, second only to that which, by virtue of its destructiveness, it possesses for the agriculturist.

# THE COLORADO BEETLE.

(*Doryphora 10-lineata*, Say.)

[Order, COLEOPTERA ; Family, CHRYSOMELIDÆ.]

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## ITS PAST HISTORY.

THIS destructive insect commonly known as the Colorado Potato-bug, or simply as the Potato-bug\* was first described under the scientific name of *Doryphora decemlineata*, in the year 1824, † by Thomas Say, who was then acting as naturalist to Long's exploring expedition to the Rocky Mountains. The specimens from which his description was made had been collected in the region of the

\* Entomologically the term "bug" is confined to a single order of insects—the *Hemiptera*—and it is most correct and less misleading to say "potato-beetle." America is the only English-speaking country in which all insects, indiscriminately, are popularly denominated "bugs," and with the spread of entomological knowledge, the custom will doubtless become obsolete.

† "Journal of the Academy of Natural Sciences of Philadelphia," Vol. III,



Upper Missouri, and it was at that time not uncommon there. The original food-plant of the beetle was subsequently found to be the Sand-bur (*Solanum rostratum*, Dunal), a species of wild potato peculiar to the region of the Rocky Mountains.

As civilization advanced westward, and potatoes began to be grown in its native home, this insect gradually acquired the habit of feeding upon the cultivated potato; and in 1859, it had spread eastward and reached a point one hundred miles to the west of Omaha city, in Nebraska. In 1861, it invaded Iowa, gradually, in the next three or four years, spreading eastward over that State. In 1864 and 1865, it crossed the Mississippi, invading Illinois on the western borders of that State, from the Eastern borders of North Missouri and Iowa, upon at least five points on a line of two hundred miles. The first published account of the destructive propensities of the species may be found in the *Prairie Farmer* for August 29th, 1861, in a letter from Mr. J. Egerton, of Gravity, Iowa, who stated that "they made their appearance upon the vines as they were up, devouring them as fast as they grew." From that time forth frequent reports of the species' great destructiveness west of the Mis-

Mississippi appeared in most of the Agricultural papers. In October, 1865, Benjamin D. Walsh, of Illinois, furnished to the *Practical Entomologist* an extended description of the new invader from the West, together with an account of its habits so far as they had been investigated; and in the same article expressed the conviction that in all probability it would in future years "travel onwards to the Atlantic, establishing a permanent colony wherever it goes, and pushing eastward at the rate of about fifty miles a year." (*Practical Entomologist*, Vol. I. No. 1.) A remarkable peculiarity in the eastern progress of this insect was subsequently pointed out by the same writer, in 1866, namely, "that in marching through Illinois in many separate columns, just as Sherman marched to the sea, the southern columns of the grand army lagged far behind the northern columns." (*Ibid*, II. p. 14.) By the autumn of 1866 the beetle, which appears to have invaded the south-west corner of Wisconsin at as early a date as 1862 (*Ibid*, II. p. 101) had already occupied and possessed a large part of the cultivated and southern portions of that State; and in Illinois, if we draw a straight line to connect Chicago with St. Louis, nearly all the region lying

to the north-west of that line was overrun by it. In 1867 it had already crossed the eastern borders of Northern and Central Illinois into Western Indiana, and in 1868 it extended to Central Missouri and Southern Illinois. In 1869 its presence was reported quite generally over the State, and it had even made its way into Ohio, appearing almost simultaneously in the northern and south-western portions. Its advent in the northern part of the State is thus described by a correspondent of the *Ohio Farmer* : "Having crossed the Mississippi at Rock Island the insects soon traversed the State of Illinois and reached the shores of Lake Michigan, where they might have met a watery grave, but, unfortunately their course was only deflected southward, and there were other cohorts of the invaders traversing lower parallels, so that, by convergence, the force was multiplied ; and great fears were anticipated by the potato growers of Northern Indiana and Ohio." These fears were subsequently justified. During the years 1869 and 1870 the insect was exceedingly destructive all through the North-west, and continued its eastward march at an ever-increasing rate. In July of the latter year it *invaded the province of Ontario* at two different

points, namely, near Point Edward at the extreme south of Lake Huron, and opposite Detroit, near Windsor, at the south-western corner of Lake St. Clair. During the spring and summer of 1871 the insect was unprecedentedly numerous. In March of that year the beetle was turned up in great numbers while the ground was being ploughed, especially in fields that had been planted the previous year to late potatoes ; and it subsequently swarmed on the wing in the streets of St. Louis.

The northern columns continued to advance at a rapid rate. During the summer the Detroit river was literally swarming with the beetles, and they were crossing Lake Erie on ships, chips, staves, boards, or any other floating object which presented itself. They soon infested all the islands in the west end of the lake, and by June were common around London, and finally occupied the whole country between the St. Clair and Niagara rivers. In the States they reached in some places the borders of New York and Pennsylvania. The southern columns of the army lagged far behind. Though gradually spreading, the insect had not yet touched the extreme southern counties of Mis-

souri, and made its first appearance during the year 1871 in Phelps, Reynolds, Wright, Dent, and Texas counties. In 1872 its injuries were much less severe in the West, owing to the action of its natural enemies, and the free use of Paris green, but its eastward march continued. It extended into Cattaraugus county, N. Y., and obtained a foothold as far east as Lancaster Co. Pa. The southern columns reached beyond Louisville, Ky.

In 1873 the advance guards of the vast army pushed to the extreme eastern limit of New York, and detached colonies made their appearance in the district of Columbia and in W. Virginia.

Early in the summer of 1874, I received undoubted evidence of its appearance on the Atlantic seaboard, and it was reported during the year from several parts of Connecticut, New Jersey, New York, Pennsylvania, Delaware, Maryland, and Virginia.

Its injuries also increased in its native home in the Rocky Mountains. It had formerly been observed by many western travellers that the potatoes in the mountain regions of Colorado were less affected by the insect than were those of *the Mississippi Valley*. This was natural

enough, since the wild food plants are common there, and the potato fields fewer, and more scattered than further east; and moreover the stream which first branched off from the wild *Solanum* feeders and took to feeding upon the cultivated potato, and spreading eastward, doubtless at first took no backward course. During the summer of 1874, however, the insect did great damage to the crops of its native region in all fields below the middle elevations.

The summer of 1875 in Missouri and adjacent States was so excessively wet that although the beetle was abundant enough in the spring, it subsequently became comparatively scarce and harmless, and did not again become multiplied till after the rains had ceased and the third brood had developed; by which time the crop was sufficiently matured to be out of danger. Very much the same conditions occurred all over the upper Mississippi Valley country, and as there was an increased acreage planted, the crop throughout this whole section was larger and prices lower than they had been for many years. In the Atlantic States the insect attracted much more attention. From almost all parts of New York,

New Jersey, Pennsylvania and Virginia, accounts came of the excessive numbers in which the pest made its appearance in the months of May and June. Local papers throughout the States mentioned, published records of the insect's injury, and laid the experience that had been gained in the States to the West before their readers ; while even large city dailies, like the *World* and *Herald* of New York, devoted column after column to Doryphora's consideration. Judging from the mass of accounts, the first brood was very generally neglected by those who had not before had experience with the insect, and not till the more numerous second brood appeared did the farmers awake to the importance of action, and, as far as possible, concerted action. Much injury was consequently done.

Later in the season the beetle at times swarmed in and about the large cities, and was commonly seen flying in the streets of Philadelphia and New York, as in past years it had been seen in those of St. Louis. Mr. J. J. Dean, of New York, after referring to its frequency in the streets of Brooklyn, gave me the following interesting *account of its occurrence on Coney Island* :—

On the 14th of September I picked up the enclosed specimen at Coney Island. The beach for miles was covered with them—the hummocks and sand-hills which comprise the greater part of the island were literally alive with them. In the towns of Flatbush and Gravesend, both situated in King's co.—the latter town including Coney Island within its boundaries—the ravages of this insect have been very serious. The Egg-plant seems to have afforded him his favourite article of diet. I am, however, puzzled by the fact that so many millions of them desert the fertile fields of Flatbush and Gravesend and steer for the barren acres of Coney Island, on which the principal vegetation is a coarse sea grass, which they do not seem to touch. They appear to have an irresistible tendency to travel east, and are only stopped by the waves of the Atlantic Ocean.

In the Fall the insect reached up into Vermont and extended to within a few miles of Boston, but had not yet occurred in Maine.

During the present year, 1876, the insect has swarmed in most of the New England States, and especially on the sea shore. It has extended north around Montreal, and was especially abundant as far as Trois Rivières;\* while in its eastern progress it has overrun Connecticut, Massachusetts,

\* L. Provancher in *Naturaliste Canadien*, Aug. 1876, p. 249.



Vermont, and New Hampshire, and extended some distance into Maine. At Milestone and other places in Connecticut the beetles were washed ashore in such numbers in September as to poison the air, and the captain of a New London vessel found that they boarded him in such numbers while at sea that the hatches had to be closed. At many watering places, such as Cape May, Coney Island, Long Branch, Rockaway, and Newport, they proved a great nuisance, being crushed and killed in large numbers by the continual promenading along the beach. The *New York Times* reported their impeding the progress of a train on the Central Railroad at Grinnell Station: "the rails were covered with them for a mile, and after a few revolutions of the drivers the wheels lost the friction and slipped as if oiled; \*\*\* they had to be swept off, and the track sanded before any progress was made."

#### THE INSECT'S NATIVE HOME.

As in the case of all insects that spread or are introduced from one section of country to another, it is interesting to know the original home or range of the *Colorado Potato-beetle*, so far as such can

be learned, though the question has no especial practical bearing.

Up to the autumn of 1865 it was generally supposed by economic entomologists, that this destructive insect had existed from time immemorial in the North-western States, feeding upon some worthless weed or other ; and that of late years, from some unexplained cause, it had all of a sudden taken to attacking the potato-plant.

They had, however, confounded with it an allied species, described further on as the Bogus Colorado Potato-beetle, which never attacks the cultivated potato.

Following Walsh, I have always believed that this species, which has gradually spread to the Atlantic, originally came from the mountain regions of Colorado, and the reasons given are sufficiently convincing to have been very generally accepted as valid. Nevertheless, Prof. Cyrus Thomas questions the soundness of the theory in the following language, which I quote because Mr. Thomas's views are entitled to careful consideration :

The first we hear of its attacking the potato, so far as I can ascertain, is in 1859, at which time it was in

Nebraska, about 100 miles west of Omaha ; the next we hear of it is in Iowa, in 1861, from which point its progress has been carefully noted. Now, it is not contended by any one that it travels except from potato patch to potato patch. That it manages in some way to get over intervening spaces of a few miles, is admitted, but never over spaces which require the production of intervening broods. Previous to 1859, as is well known, there was an intervening space between the border settlements of Nebraska and the eastern base of the mountains of two or three hundred miles in which there were no potato patches. How are we to account for it bridging this space ; what induced it to take up its line of march across this barren region in which there were no settlements ? Is it not much more reasonable to suppose the plains themselves formed its native habitat, and that as soon as the pioneer settlements reached this region and the potato was introduced, it commenced its attack upon it, and then began its march eastward along the cultivated area ?

*Western Rural*, December 4, 1875.

The weak points in the above reasoning are that it implies, first, that the insect travels only from potato patch to potato patch, and that there must have been potatoes at every few miles between the point west of Nebraska, where the beetle was first noticed on cultivated plants, and the mountains ; *second*, that no cultivated potatoes were grown on

said plains. In truth, however, potatoes were undoubtedly grown around Fort Kearney and other forts and settlements prior to that time, and the beetle may travel by the spreading of other wild species of *Solanum*, and by being carried along water-courses or on vehicles. One point that may be urged in favour of the supposition that the insect was indigenous to the plains that reach far eastward into Kansas and Nebraska, is that it was unobserved in potato fields by certain parties in parts of Colorado after it had reached as far as Iowa. The point is, however, weakened by the fact that it was found in great abundance in Colorado by Drs. Velie and Parry in 1864. Another point that may be made is that it is difficult to imagine that an insect, with such a natural predilection for *Solanum tuberosum*, could have passed from settlement to settlement across the plains without its depredations being noticed and recorded. But this last point may also be turned against Prof. Thomas's supposition, since it is also just as difficult to imagine that the potato patches that have been grown in restricted localities on the plains should have remained untouched, if the insect had always existed on those plains. Moreover, since potatoes

were cultivated on the eastern borders of the plains in Nebraska and Kansas long prior to 1859, there can be no good explanation why the insect did not sooner commence its eastward march, except on the theory of a natural barrier in the shape of the more barren plains, which had up to that time prevented its advance from more western confines.

Mr. Thomas, in support of his views, supposes that the Sand bur (*Solanum rostratum*) originally occurred over the plains in question, citing as proof Gray's statement that it is wild on the plains West of the Mississippi, and the localities given by Porter and Coulter in their *Flora of Colorado*. Dr. Gray's language is altogether too general to help much in the argument, and refers to the range of the plant ten years after the beetle had appeared in Nebraska. Porter and Coulter's localities are all in Colorado, and their "Plains of the Platte," doubtless refers to the south fork of that river. At all events, nothing is more certain than that the original home of the plant was the more fertile portions of the mountain region, and that, like the beetle which it nourished, it has been for many years extending its range eastward through man's agency in one way and another, and is now rapidly extending across

Missouri, where but a few years back it was entirely unknown. Mr. Carruth, of Topeka, says that prior to 1864, it was unknown in Kansas, and Mr. C. W. Johnson, of Atchison, writes me that the coming of *Doryphora* and of the weed in question were contemporaneous in that section; that the northern dispersion of the plant from the south-west, through the Texas cattle traffic, afforded the means by which the beetle passed the great stretches of prairie lying east of its native haunts.

Bearing in mind that as early as 1824 Say reported the beetle sufficiently common on the upper Missouri, and that it flourishes most in the more northern of the States, I think we may justly conclude that the native home of the species is the more fertile country east of the mountains, extending from the Black Hills to Mexico, where it becomes scarce, and is represented by *Doryphora undecemlineata* and *D. melanothorax*. Putting all the facts together we may also conclude that it crossed the great plains through man's agency. That it first reached the more fertile cultivated region to the east, in Nebraska, finds explanation, perhaps, in the fact that travel was greatest along that parallel, and that the insect's natural range extended further

eastward in those more northern parts, just as the mountain region does in Wyoming and Dakota.

On the whole, Walsh's theory is doubtless at fault, and needs modification in so far as it implies that the insect necessarily came from Colorado ; still I can but think that our *Doryphora* came from the Rocky Mountain region, and that civilization, in the way of traffic, travel, and settlement on the plains, was the means of bringing it, and that if we put not a too strict construction on his language, Walsh's views are in the main correct.

#### RATE AT WHICH IT TRAVELLED.

Walsh estimated, from the rate at which it travelled in the earlier history of its march, that it would reach the Atlantic in 1881. From subsequent calculations I placed the date at 1878, but it in reality touched the Atlantic seaboard at many different places in 1874. It thus spread at an average annual rate of about 88 miles. But the annual rate was by no means uniform. Earlier in the history of its march the rate was much lower, and, until it got east of the Mississippi, did not average fifty miles. The line of most rapid spread was *along the line of greatest human travel and traffic.*

In fact, after it had reached New York it began to extend and swarm both north and south along the coast, before many of the inland counties on similar parallels were reached by the main line of the immense army.

#### HOW IT TRAVELLED.

As the larva is sluggish and never leaves the plant from which it is hatched, except in quest of more food, until it is ready to pupate, all the journeys of this insect are necessarily made in the perfect or beetle state by means of the ample rose-coloured wings, which, when the insect is at rest, are compactly folded up beneath the striped wing-cases. Its spread, however, over the more populous portions of the country, is not to be attributed to its powers of flight alone. It undoubtedly availed itself, to no inconsiderable extent, of every means of transportation afforded to other travellers, and often got a lift on eastern bound trains, and, as we have seen, most probably crossed the more barren plains bordering its native confines through man's direct agency, *i.e.* by being carried. There is a possibility that in some instances it may have been carried in the egg state on living plants, or in the pupa state in lumps of earth; but



these modes of transit, if they have occurred at all, have necessarily been exceptional. Even the winds and waters aided its progress. Its invasion of Canada took place at precisely the two points where we should expect to first meet with it in the Dominion, namely, at the extreme south of Lake Huron, and at the south-western corner of Lake St. Clair; for all such beetles as fly into either of the lakes from the Michigan side would naturally be drifted to these points, and be washed to the shores of the St. Clair and Detroit rivers. As we know from experience, many insects that are either quite rare or entirely unknown on the western side of Lake Michigan, are frequently washed up along the lake shore at Chicago; and these are so often alive and in good condition, and so often in great numbers, that the lake shore is considered excellent collecting ground by entomologists. In like manner locusts are often washed up on the shores of Salt Lake in Utah, in such countless numbers that the stench from their decomposing bodies pollutes the atmosphere for miles around. I have not the least doubt, therefore, in view of these facts, that the Colorado Potato-beetle could survive a sufficient *length of time* to be drifted alive to Point Edward,

if driven into Lake Huron anywhere within twenty or thirty miles of that place, or if beaten down anywhere within the same distance while attempting to cross the lake.\*

We have already seen how, in 1870, the beetles crossed Lake Erie on ships, chips, staves, boards, and any other floating object that presented itself, while the Detroit river literally swarmed with them.

An incident related to me by Jno. Hurlburt, Jr., who was engaged at the time in surveying and prospecting on the southern shore of Lake Superior, will illustrate how great a distance the beetles may extend without food when aided by water : he found them in immense quantities on a potato patch belonging to some Indians on the Meno-

\* The following item, which was clipped from the St. Joseph (Mich.) *Herald*, attests the accuracy of the inference :—"Whoever has walked on this shore of Lake Michigan has observed large numbers of the Colorado Potato-beetle, crawling from the water. Many have doubted the source whence they came. It would seem from the following that they fly and swim from the western shores of Lake Michigan. Capt. John Boyne, of the *Lizzie Doak*, reports finding his deck and sails infested with potato bugs when half way from Chicago to St. Joseph at night. Not a bug was on deck when the schooner left Chicago."

monee river ; yet this potato patch was in a clearing of about twenty acres, with no other clearing near ; and to his certain knowledge there could not have been another potato patch within one hundred and fifty miles.

Many insects that are subject to very great multiplication, though not naturally migratory, often acquire the habit of migrating in swarms from one part of a country to another ; and the migrating tendency has at times been quite marked in our *Doryphora* during its eastward march. This tendency is particularly noticeable in the last or Fall brood, and I have seen the beetles in autumn, swarming in the air or travelling in immense armies on foot—all instinctively taking the same direction, which is indeed a peculiarity of all animal migrations. There can be little doubt, therefore, that the larger areas have been traversed by this insect in the latter part of the growing season.

IT SPREADS, BUT DOES NOT TRAVEL IN THE SENSE  
OF LEAVING ONE DISTRICT FOR ANOTHER.

Let it not be understood that this insect, in its *onward spread*, or march, ever entirely quits any

district where it has once obtained a foothold. This idea of its itinerant character seems very generally to prevail, and a great many people labour under the impression that soon after its advent, this dreaded foe to the potato will of its own accord take its leave as suddenly as it came—that, like every other dog, it will have its day. This idea is rather encouraged, though I believe unintentionally, by Dr. Le Baron in his first Illinois Entomological Report, where he gives it as his opinion that the beetle will in time disappear, “especially in those localities where it is most abundant, even though we leave the work wholly to Nature.” Nothing could, however, be farther from the truth, or less in accordance with past experience. It may, and very generally does, prove more injurious during the first two or three years of its advent than subsequently; because time is required for its natural enemies to multiply sufficiently to keep it in check. But wherever it once obtains a footing, there it may be expected to remain for all time to come—vacillating, it is true, from year to year, in numbers and consequent power to do mischief, according as the conditions for its increase or decrease are favourable; but always present to take

its chances in the great struggle for existence, and to get the upper hand if it can.

#### AREA INVADED BY JT.

From the foregoing account it is manifest that this pernicious beetle has spread over an area of nearly 1,500,000 square miles, or considerably more than one-third the area of the United States. It has travelled over two-thirds of the continent in a direct eastern line, and at least 1,500 miles of this distance since 1859. It occupies at the present time, more or less completely, the States of Colorado, Nebraska, Kansas, Minnesota, Iowa, Missouri, Wisconsin, Illinois, Michigan, Indiana, Kentucky, Ohio, New York, Pennsylvania, District of Columbia, Virginia and West Virginia, Maryland, Delaware, New Jersey, Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, and Maine, in none of which it was autochthonous except the first mentioned. If we wish to outline the whole territory now occupied by it, we must add to the above, parts of Wyoming and Dakota, where it was native, and a large portion of Canada.

## CAUSES WHICH LIMIT ITS SPREAD.

There are reasons why the Colorado Potato-beetle did not spread as rapidly along the line of its southern as along that of its northern march. The first is, that the potato is not in such general cultivation along the latter as along the former parallel, and potato fields are therefore more scattered; the second, that the insect was northern rather than southern in its native habitat; the third, that it suffers and does not thrive where the thermometer ranges near 100° F. The larvæ frequently perish under such a broiling sun as we sometimes have at St. Louis, and during very hot, dry weather, it frequently fails, as it did in 1868, to successfully go through its transformations in the ground, which becomes so hot and baked that the pupa dries out, and the beetle, if it succeeds in throwing off the pupal skin, fails to make its way to the surface. For these reasons it may never extend its range very far south of the territory now occupied. Its northern spread is not limited by any such cause, and the intensity or length of the winter will hardly affect it except in reducing the number of possible annual broods, and consequently

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its power of multiplication. The state of dormancy once entered into may continue a month or two, more or less, without seriously affecting most insects. We may expect, therefore, to see it push to the northernmost limit of the potato-growing portion of the country—a limit which it has already well-nigh reached.

The question whether it will extend further westward and reach the Pacific, is a more interesting one. There is the best reason for believing that the Rocky Mountains furnish an impassable barrier to it, as they do to so many other insects. It has already been shown how potatoes in the mountains were for years less affected than were those of the Mississippi Valley; but that in 1874 the insect proved quite injurious to those of the mountain region of Colorado. The fact is well-established that it has not reached more than three or four miles into the mountains, or to about the middle elevations—say 8,000 feet above the sea level. The reason is that the atmosphere above that level is so dry and attenuated, that, taken in connection with the cool nights, the eggs, or the larvæ that succeed in hatching from them, shrivel and dry up. We have here, therefore, a physical barrier to its further

westward progress, and the beetle is no more likely to reach California without man's direct assistance and carriage than it is to cross the Atlantic Ocean without the same means. Whether it could thrive on the Pacific coast where the summers are so dry, is another question; but I fear it would hold its own, in many portions, if once introduced. In this connection it will be well to state that geographical races of *Doryphora 10-lineata*, differing in no very important characters from the typical northern specimens, occur in S. Texas, New Mexico, Arizona, and Mexico, though they seem to have no more acquired the potato-feeding habit than *D. juncta* has done.

#### HOW IT HAS AFFECTED THE PRICE OF POTATOES.

During the earlier years of the insect's devastations in the Mississippi Valley, it materially affected the price of potatoes, not only by its direct ravages, but by discouraging farmers from attempting to cultivate the crop on an extensive scale. In 1873 the price reached the high figure of \$2.00 per bushel (wholesale) in the St. Louis market, and many a family had to forego the luxury of a product which a few years before had been one of the



cheapest of the farm, and so abundant as to enter largely into the feed of all kinds of stock. At the present time, with the improved methods of fighting the enemy, there is no longer the same dread of it in the Western States that formerly existed: its management is considered part of potato-culture, and its natural enemies assist man to that degree that its effect on the crop is less felt. The quality of the tuber was very seriously affected through the defoliation which the vines so generally endured, and it was at one time difficult to get a non-watery potato on our western boards.

THE MODIFICATION IT HAS UNDERGONE.

Under the head of food plants it will be presently shown how the species, as it spread over the country, became modified in habit, and increased the number of its food-plants. It has also undergone considerable modification in character. Specimens which I have examined from different parts of the country, show great variation in the marks of the thorax, in size, in coloration, and even in the ornamentation of the elytra, or wing-covers, and legs. The yellow varies from deep gamboge to *almost pure white*, the black line along the elytral

suture is either very distinct or as obsolete as in *juncta*; while some specimens have the pale legs and the femoral spot, more or less distinct, which are so characteristic of this last. In northern Iowa and Wisconsin I have seen millions travelling over the ground, the average size of the individuals being not more than half that of the more typical specimens; and the general ground-colour being white rather than yellow. In its southern range the colours tend to brighten and the black to become more metallic. Indeed the variation which it has already exhibited furnishes interesting material for the close species makers; but it will suffice here to indicate that it exists: its consideration more in detail belongs elsewhere.

#### ITS NATURAL HISTORY.

The natural history of this insect was first made known by the author in the columns of the *Prairie Farmer*, for August 8th, 1863. Subsequently, in 1866, Dr. Shimer, of Mt. Carroll, Ill., detailed some additional particulars bearing on its habits, in a paper which he published in the *Practical Entomologist* (Vol. I. pp. 84—85). The Colorado Potato-beetle hibernates in the perfect state,

beneath the surface of the ground, or under any rubbish or other shelter that it can find. It has been exhumed from depths varying from a few inches to several feet, though its habit is not to burrow deeper than ten inches. The beetles are often dug up or ploughed up in April, and they issue from their winter quarters soon after the ground thaws out, and at this season fly readily during the warmer parts of the day, making aerial journeys of considerable extent.

In flight the striped elytra are raised and held motionless from the thorax, while the gauzy wings, unfolded and vibrating, strike pleasantly on the eye as the sun intensifies their rosy hues.

The females begin to lay their eggs upon the young potato plants—mostly on the underside of the leaves—as soon as the latter appear above ground, and will often work into the ground to feed upon the young leaves before these have fairly shown themselves. The eggs are oval, of a translucent dark orange colour, and are deposited in clusters of from 10 to 40 on the under sides of the leaves. The larvæ are hatched in less than a week, and are at first of a dark Venetian red, becoming *lighter and acquiring a double row of black lateral*

spots as they approach maturity. The legs, head, and posterior half of the first joint are also black. In from two to three weeks these larvæ acquire their full growth, after which they enter the earth and undergo their transformations, first to the pupa and then to the beetle state, which last is assumed in about a month from the time of hatching. There are three broods or generations each year in the latitude of St. Louis: yet it may be found at almost any time during the summer in all its different stages. This is owing to the fact that the eggs in the ovaries continue to develop, and are laid in small batches at short intervals during a period of about forty days in summer. The number produced by a single female averages from 500 to 700, but has been known to reach over 1,000. The whole cycle of transformations from the egg to perfect beetle rarely requires more than a month, and the last brood of beetles issue from the ground early in the fall, and, as we have just seen, enter it again to pass the winter.

#### ITS POISONOUS QUALITIES.

This question has been much and freely discussed in the columns of the agricultural press since the

year 1866, and the war of divided opinion and diverse experience has waged briskly. That the juices of the insect on the human skin, are, as a rule harmless, is proven by the hosts of farmers who have, with impunity, crushed the pest by hand ; indeed, scarcely any one who has had experience believes the wild stories of the poisonous nature of these juices. Yet the rule is not without exceptions ; there is no doubt that, with blood in certain bad conditions, persons have been poisoned by getting said juices into wounds or cuts. But the cases of undoubted poisoning by this insect—cases that have in some instances been serious and even proved fatal—are not from the juices of the body, but from the exhalations resulting from the *bruising* or crushing of large masses ; especially by burning or scalding large quantities at a time. The poison seems to be of a very volatile nature, and to produce swelling, pain, and nausea, very much as other animal poisons do. In the writer's reports, as well as in the first report of Dr. Wm. Le Baron, formerly State Entomologist of Illinois, authentic instances of such poisoning are recorded. Therefore, while there can be little danger in the cautious killing of the insect in the field, it should

not be recklessly handled in large quantities, and its destruction, in such quantities, by scalding or burning, should be especially avoided.

Some interesting experiments, to test the poisonous qualities of these insects, were made in 1875, by Messrs. A. R. Grote and Adolph Kayser, and reported in a paper entitled "Are Potato Bugs Poisonous?" read before the American Association for the Advancement of Science at its meeting in Detroit. The experimenters conclude that the reported cases of poisoning resulted rather from the arsenic used in destroying the insect, or from carbonic oxide produced by incomplete combustion when large numbers of the beetles are thrown into a fire. It is to be hoped that the experiments will be continued, because, so far, they by no means cover the whole ground; we have yet to learn what the active principle is which produces the physiological effect that has been well attested, and the precise conditions under which it acts.

It is worthy of note that Prof. A. J. Cook, of the Michigan Agricultural College, from experiments somewhat similar to those of Messrs. Grote and Kayser, has been led to form conclusions quite opposite to those arrived at by these gentlemen.

## ITS FOOD PLANTS.

In its native home the Colorado Potato-beetle fed upon the few wild species of *Solanum* found there, especially *S. rostratum* and *S. cornutum*. It still often shows a preference for these wild plants to the cultivated potato. For a number of years it was thought that the insect was incapable of flourishing on any other plants but those of the Nightshade family (*Solanaceæ*), and more especially upon those of the Nightshade genus proper (*Solanum*), which includes the Egg Plant, the Horsenettle, and some other wild species west of the Mississippi, which are known by various popular and local names. Upon the Horsenettle (*S. Carolinense*), which is common in Missouri and east of the Mississippi, but is mostly replaced in Kansas by the *S. rostratum*, it seems to delight even more than upon the potato, and it has been found quite injurious to other plants of the same genus, such as the *S. Warscewiczii*, *S. robustum*, *S. discolor*, and *S. Siegelii*, which are often cultivated for their ornamental foliage. The other common plants of the family, such as the Tomato (*Lycopersicum*), Ground cherry (*Physalis*), Thorn apple (*Datura*),

Henbane (*Hyoscyamus*), Apple of Peru (*Nicandra*), Tobacco (*Nicotiana*), Belladonna, Petunia, and Cayenne Pepper are not overmuch to its liking, though upon a pinch it will feed upon all of them, and especially the first-named. Dr. Le Baron observed that the Cayenne pepper, if caten to any extent, was actually poisonous to it.

Under these circumstances it is interesting to note (as showing how new habits may be acquired under favourable conditions), that as the insect became more and more acclimated east of the Mississippi, it acquired the power to feed on a greater variety of plants, and did not even confine its depredations to those belonging in the natural Order *Solanaceæ*. In 1871 it was found by several parties feeding, and even breeding in considerable numbers, on cabbage. It would be sad indeed if so important an esculent should in the future be doomed to suffer with the potato, from the insatiable appetite of such a pest; and though I have no idea that cabbage raisers need fear anything of the sort, yet stranger things have happened.

In 1874 Mr. Henry Gillman, of Detroit,



Michigan, added to the list of its food plants several new species, on which, in one state or another, he found them feeding. I quote the following from a letter in which he recounted to me these observations, with the remark that the fact of finding the eggs on a plant, or the insect sparingly nibbling the same, does not prove that it could live and thrive on such plant, as a species, any more than the fact that a cow at times partakes sparingly of animal food proves that she could sustain life on a flesh diet. Yet the facts communicated by Mr. Gillman are interesting, as showing the tendency to which I have before alluded, toward a change of habit from year to year, as the insect changes and extends its habitat :—

I found the *Doryphora 10-lineata*, Say, at Port Austin, Michigan, on June 19, 1872, feeding sparingly on young grass (too immature to determine its species), on which the insect had deposited its eggs. This was generally, though not always, in potato fields or their vicinity. On July 20 (about a month later) I found the insect at Fort Gratiot, Michigan, in large numbers, both larva and perfect states, in the vicinity of potato fields which it had almost destroyed, devouring the young leaves and flower-buds of the common thistle (*Cirsium lanceolatum*, Scop.),

which it was rapidly stripping. In the same neighbourhood I saw it on Pigweed (*Amarantus retroflexus*, L.), Hedge Mustard (*Sisymbrium officinale*, Scop.), the cultivated Oat, Smartweed (*Polygonum Hydropiper*, L.), and the Red Currant and Tomata of the gardens, as well as the common Nightshade (*Solanum nigrum*, L.); of which, with the exception of the Nightshade, its more legitimate food, it ate only the young leaves, and of them very sparingly. Two or three weeks later I found the thistles devoured by it even to the thick stems, so that all the leaves were stripped off, and the entire tops of the plants hung down, almost severed. About the same time I saw the insect feeding on the maple-leaved Goosefoot (*Chenopodium hybridum*, L.), Lamb's quarter (*U. album*, L.), and Thoroughwort (*Eupatorium perfoliatum*, L.), and on August 8, 1872, I found it, in both the larva and perfect states, voraciously eating the Black Henbane (*Hyoscyamus niger*, L.), on which was also to be seen an abundance of the eggs. As the last-mentioned plant is not native, having been introduced from Europe, the beetle's fondness for it is more noteworthy.

Mr. A. W. Hoffmeister, of Ft. Madison, Iowa, an entomologist, the accuracy of whose observations may be relied on, wrote during the same year:—

Last year, after all the early potatoes had been taken up and the late ones either wilted through excessive dryness or eaten up by the Colorado gentleman, I was astonished to find so many 10-lined spearmen in the

lower part of town, while in the upper part they were reasonably scarce; but I was more astonished to find that the larvæ had stripped the *Verbascum* of its leaves.

The Mullein, belonging to the Figwort family, must therefore be added to the list of plants on which the insect lives and flourishes. An item went the rounds of the papers during that year to the effect that Alfalfa was greedily devoured by the insect; but just how much credit should be given to the statement, which originated with a Montana correspondent of the *Farmer's Home Journal* of Kentucky, it is difficult to say. Probably the reference was originally made to the old-fashioned "potato-bugs," or blister-beetles, which are common in the Western country and very general feeders.

This growing ability to adapt itself to a greater variety of food-plants will render its extermination and control all the more difficult.

Several instances came under my notice where the beetles, in early spring, entered hot-beds in great numbers, and devoured tender tomato and egg-plants.

Among the Potatoes, the tender-leaved varieties, such as the Shaker Russet, Mercer or Meshannock,

Pinkeye, and Early Goodrich are most affected, while the Peach Blow, Early Rose, and the like, enjoy comparative immunity, especially when grown in the same field with the more tender varieties which attract the greater proportion of the pests.

#### THE BEETLE EATS AS WELL AS THE LARVA.

As the statement has been quite frequently made that the beetle does not feed, and that consequently there is nothing to fear from it early in the year, the fact may as well be reiterated that the beetles do feed, though not quite so ravenously as the larva. But as they are on hand as soon as the young plants peep through the ground, and as these first spring beetles are the source of all the trouble that follows later in the season, it is very important to seek and destroy them.

#### ITS NATURAL ENEMIES.

Persons not familiar with the economy of insects are continually broaching the idea that, because the Colorado Potato-beetle is in certain seasons comparatively quite scarce, therefore it

is about to disappear and trouble them no more. This is a very fallacious mode of reasoning. There are many insects—for instance, the notorious Army-worm of the North (*Leucania unipuncta*, Haworth)—which only appear in noticeable numbers in particular years, though there are enough of them left over from the crop of every year to keep up the breed for the succeeding year. There are other insects—for instance, the Spring Canker-worm (*Paleacrita vernata*, Peck)—which ordinarily occur in about the same numbers for a series of years, and then, in a particular season, and in a particular locality, seem to be all at once swept from off the face of the earth. These phenomena are due to several different causes, but principally to the variation and irregularity in the action of cannibal and parasitic insects. We are apt to forget that the system of Nature is a very complicated one—parasite preying upon parasite, cannibal upon cannibal, parasite upon cannibal, and cannibal upon parasite—until there are often so many links in the chain that an occasional irregularity becomes almost inevitable. Every collector of insects knows that scarcely a single season *elapses* in which several insects, that are ordi-

narily quite rare, are not met with in prodigious abundance; and this remark applies, not only to the plant-feeding species, but also to the cannibals and the parasites. Now it must be quite evident that if, in a particular season, the enemies of a particular plant-feeder are unusually abundant, the plant-feeder will be greatly diminished in numbers, and will not be able to expand to its ordinary proportions until the check that has hitherto controlled it is weakened in force. The same rule will hold with the enemies that prey upon the plant-feeders, and also with the enemies that prey upon those enemies, and so on *ad infinitum*. The real wonder is, not that there should be occasional irregularities in the numbers of particular species of insects from year to year, but that upon the whole the scheme of creation should be so admirably dove-tailed and fitted together, that tens of thousands of distinct species of animals and plants are able permanently to hold their ground, year after year, upon a tract of land no larger than an ordinary State.

To the naturalist it has been interesting to watch how, with the advance of the *Doryphora* toward the East, the number of its natural enemies has

increased. The farmer should learn to distinguish these his allies, and to encourage them.

Several birds are known to feed upon both beetles and larvæ. Among these is the Crow, which not only takes the beetles from the potato vines, but late in the season digs into the earth in search of the hibernating individuals. The common quail too, that blythe and pretty field companion, whose services as an insect gatherer have been altogether underrated, performs the same service for us.

In July, 1872, Prof. C. E. Bessey, of Iowa Agricultural College, wrote me word that he found the Rose-breasted Grosbeak (*Guiraca ludoviciana*) devouring the Potato-beetles, and soon afterward, the same bird was sent to me by E. H. King, of Steamboat Rock, Iowa, with a similar statement. Other persons, especially in Iowa, observed the same trait in this bird, which, though formerly quite rare, seems during that year to have suddenly multiplied and acquired this habit. Mr. Joel Barber, of Lancaster, Wisconsin, informed me that this bird, though seldom seen there before, was quite common in that vicinity about the first of June, breeding there, and clearing potatoes of

the nasty "bugs," which it seemed to prefer to all other food. Ever since then it has effectually assisted the north-western potato-grower in protecting his fields.

The Rose-breasted Grosbeak is a beautiful and conspicuous bird, the male having a heavy bill, with black head, black back, varied with brown, and black wings, the latter with three white bands. Some of the outer tail-feathers and parts of the abdomen are white, and the breast is rose-red.

Among domesticated birds, the duck was for several years the only species that would touch the nauseous insects, and for a long time chickens would invariably give them the go-by. After a few years, however, chickens learned to eat, first the eggs, and then the larvæ, and finally acquired the habit of feeding upon the mature insects to such an extent that instances have been reported to me where between thirty and forty perfect beetles had been found in the crop of a single chicken, and this not from lack of other food but from preference.

Among quadrupeds there is good evidence that the skunk feeds upon them. That good garden servant, the common toad (*Bufo Americanus*), often gorges itself with them, while the black



snake and doubtless other reptiles in this respect keep it company.

Among spiders (*Arachnida*) an undetermined species of *Phalangium*, has been seen preying upon our *Doryphora* larva. These animals are popularly called "Grand-daddy Long-Legs," in this country, but are also known as "Harvest-men," and "Grandfather Gray-Beards," in some parts. They all have similar habits, being carnivorous and seizing their prey very much as a cat seizes a mouse, but differ from other spiders in that they bodily devour their victims, instead of sucking out their juices. They are known to devour great numbers of plant-lice, and Mr. Arthur Bryant, of Princeton, Ill., found them devouring the larvæ of our Colorado immigrant.

Of mites (*Acarina*), there is a very interesting species (*Uropoda Americana*, Riley), which is parasitic on the beetle externally. It was first sent to me by Mr. H. C. Beardslee, of Paynesville, Ohio, in 1873, and subsequently found by Mr. W. R. Gerard, to very generally infest the beetles around Poughkeepsie, N. Y. It sometimes so thickly crowds and covers its victim that no part of this last is exposed, and the beetle thus

infested languishes and eventually perishes. This minute parasite is about the size of the head of a small pin, broadly oval, depressed, the body in one piece, somewhat tough above, and yellowish-brown in colour. It is not uncommon on other beetles, and is closely allied to a well-known European mite parasite of beetles and other Articulates—the *Uropoda vegetans*. This last is described by authors as possessing the peculiarity of attaching itself to the hard, shelly parts of its victims by means of a thread-like filament, that issues from the posterior part of the body. A careful study of our American species has convinced me that the similar anal filament, which also helps it to adhere to *Doryphora*, is in reality excrementitious, sticking to the beetle and to the mite by a flattened disc at either end, being quite fragile and easily broken. The true penetrating organs, which enable the mite to hold tenaciously to its victim, and probably assist in obtaining nourishment, I have discovered to be a pair of extensile processes, each armed at the tip with a small claw somewhat resembling that of a lobster. When at rest these organs are retracted and lie between the legs and just under the skin. When

extended, they are usually brought closely together and extend the whole length of the animal beyond the head. Thus, in addition to the more frail excrementitious and adhesive filament, this *Uropoda* is provided with an organ that is beautifully adapted to penetrating the hard covering of beetles, and of thus securing it to its slippery support.

The most effective natural enemies of our potato pest, are, however, found among insects proper, and—determined as man's warfare has been against it, with his mechanical appliances, and poisonous preparations—it is doubtful whether his efforts would have been availing without the aid of these tiny but by no means insignificant allies. A few prey upon the beetle, but the larger number attack the eggs and larvæ. I will give brief illustrated accounts of the more notable of them, according to their several orders :

Ord. *Hymenoptera*.—Though this, of all the Orders, contains the largest number of parasitic species, yet not one of them is known to attack the *Doryphora*, and the only Hymenopteron that has been observed to attack it is the Rust-red Social Wasp (*Polistes rubiginosus*, St. Farg.), which has been seen to carry the *Doryphora* larva to its nest.

The wasps of this genus, with their gray paper-like nests, are familiar objects. A solitary female or queen that has hybernated, founds the colony, feeding her larvæ on honey and various partly masticated insects. Her immediate progeny is composed of females only, somewhat smaller than herself. There are no males in this summer brood, and the virgin females build a nest in common, and produce a fall generation, composed of both sexes, the large females of which, after impregnation, hibernate, and start, each one, a colony again the following spring.

Ord. *Coleoptera*.—This Order furnishes quite a number of Doryphora's enemies, and first in importance among them are various species of Ladybirds (*Coccinellidæ*). The following species have all been found by myself and others preying voraciously upon its eggs: 1.—The Spotted Ladybird (*Hippodamia maculata*, De Geer), which is one of our most common species, and is of a pink colour, marked with large black spots. 2.—The Nine-spotted Ladybird (*Coccinella 9-notata*, Herbst), which is of a brick-red colour, and marked with 9 small black spots. 3.—The Thirteen-spotted Ladybird (*Hippodamia 13-punc-*

*tata*, Linn.), which is also of a brick-red colour, but marked with 13 black spots. 4.—The little species which may be known as the Convergent Ladybird (*Hippodamia convergens*, Guer.), and which is of an orange-red colour marked with black and white. This last species alone has been of immense benefit in checking the ravages of the Potato-beetle. Its larva is blue, orange, and black; when full grown it hangs by the tail to the underside of a stalk or leaf, and transforms into the pupa. In this state it is of the exact colour of the Colorado beetle larva, and is doubtless quite often mistaken for that larva, and ruthlessly destroyed. It may readily be distinguished, however, by its perfect repose. Let every potato grower learn well to recognize it and spare its life!

5.—The Icy Ladybird (*Hippodamia glacialis*, Fabr.). This species, which was doubtless so named from occurring so far north, where it is often found under ice and snow, has likewise been seen in great numbers carrying on the same commendable work. The wing-covers are of a bright orange-red, each marked behind with three black spots, the two upper of which are confluent, and the head and thorax being black, marked with

cream-yellow. The species is closely allied to the Convergent Ladybird (differing principally in being nearly twice as large, and in lacking the spots on the anterior portion of the wing-covers), and will be found to have similar transformations. 6.—The 15-spotted Ladybird (*Mysia 15-punctata*, Oliv.). This is the largest of our true Ladybirds, and the only other species of the family that is larger, in this country, is the Northern Squash-beetle (*Epilachna borealis*, Fabr.), a species which has the wing-covers spotted in a somewhat similar manner, and which is common in some parts of the East. The 15-spotted Ladybird is a very variable insect. In the more common form the thorax is cream-coloured, and the wing-covers cream-coloured, with a tinge of chocolate. In this form the black spots and marks are conspicuous. In another the thorax remains the same, but the wing-covers are chocolate-brown, and the black spots are surrounded with a paler brown annulation. In a third form the thorax is a little darker, and the wing-covers so dark that the spots are scarcely perceptible; while in a fourth, the whole insect is of a uniform deep brown-black colour.

The larva of this beetle is jet black, with six

rows of long spines and six long black legs. It has a paler yellowish stripe along each side, intercepted by two bright orange spots behind the legs, and there is also an orange spot on the back of the flattened first joint. When about to change, this larva fastens itself to the plant and changes to a cream-yellow pupa, marked with black.

All these Ladybirds devour by preference the eggs of the Potato-beetle, and thus attack it in the most susceptible condition. The two larger species, and notably the last mentioned, also attack the *Doryphora* larva. The larvæ of all these Ladybirds are more bloodthirsty in their habits than the perfect beetles, and the larva of the little Convergent Ladybird is so essentially cannibal, that whenever other food fails, it will turn to and devour the helpless pupæ of its own kind.\* It is rather cruel, and withal a somewhat cowardly act, to thus take advantage of a helpless brother; but in consideration of its good services, we must overlook these unpleasant traits in our little hero's

\* This is so generally the case with predaceous insects, that the term "cannibal" is often employed by entomologists, and is sometimes employed in this work to designate the rapacious or *insectivorous* species.

character! All these larvæ bear a strong general resemblance. They run with considerable speed, and may be found in great numbers upon almost all kinds of herbage. The larvæ of certain species that prey upon the Hop Plant-louse in the East, are well known to the hop-pickers as "black niggers" or "serpents," and are carefully preserved by them as some of their most efficient friends.

The eggs of Ladybirds greatly resemble those of the Colorado Potato-beetle, and are scarcely distinguishable except by their smaller size, and by a much smaller number being usually deposited in a single group. As these eggs are often laid in the same situation as those of *Doryphora*, the farmer should learn not to confound those of his best friends with those of his bitterest enemies. A practised eye soon discriminates between them, and it is often on such minute discriminations that we must distinguish between friend and foe.

Next in importance, among the beetles, as enemies of *Doryphora*, come certain Tiger-beetles (*Cicindelidæ*), and Ground-beetles (*Carabidæ*), which are quick of limb, very voracious, and devour indifferently the larva or the beetle. I



will describe a few that have been found doing this good work, though many others of the same family doubtless also prey upon the potato pest, as the different species are not at all particular as to diet.

1.—The Virginia Tiger-beetle (*Tetracha Virginica*, Hope), is of a dark metallic green colour, with brown legs.

2.—The Fiery Ground-beetle (*Calosoma calidum*, Fabr.), is of a black colour, with coppery dots. Its larva is a black, elongate, six-legged creature known as the "Cut-worm Lion," on account of the avidity with which it hunts for, and destroys, those garden and field pests.

3.—The Elongate Ground-beetle (*Pasimachus elongatus*, Lec.), a pretty and conspicuous insect of a polished black colour, edged with deep blue, and of a rather elegant form.

4.—The Murky Ground-beetle (*Harpalus caliginosus*, Say), which is of a dull black colour.

In 1871 the Great Lebia (*Lebia grandis*, Hentz), was found devouring the larvæ of Doryphora; and during the subsequent year this beetle, hitherto considered rare, was found to be very abundant in certain potato fields in Central Missouri, where it was actively engaged in destroying

both the eggs and the larvæ of the same. The head, thorax, and legs of this cannibal are yellowish-brown, in high contrast with its dark-blue wing-covers. Mr. P. R. Uhler subsequently found the Black-bellied Lebia (*Lebia atriventris*, Say), a species of the same colour and general appearance, but only half as large as *L. grandis*, destroying it around Baltimore.

The same commendable habit is ascribed to the Kansas Bombardier beetle (*Brachinus Kansanus*, Lec.), an insect likewise bearing a general resemblance to the Great Lebia, but one-third larger and more lengthened, and with the wing-covers of a duller, less polished blue. The beetles of this genus all have the power of discharging from the anus, when disturbed, an acrid fluid of so volatile a nature, that upon coming in contact with the air, it tennuates with an explosive noise and pungent smell, and hides the artilleryman in a bluish vapour which enables him to effect his escape. The species in question was first found attacking the Doryphora larvæ by Mr. Thomas Wells, of Manhattan, Kansas, who furnished me with specimens for identification.

To those above enumerated may be added a species

of Rove-beetle, belonging to the genus *Philonthus*. An undescribed species of this genus was found by Dr. Shimer, killing the *Doryphora* larvæ in one of his breeding cages, and there is reason to believe that it follows the same habit when free in the field. The particular species noticed by Dr. Shimer was in the Walsh cabinet, which was destroyed in the great fire at Chicago. The larvæ are active and voracious, and bear considerable resemblance to the perfect insects. The pupæ are quiescent and incapable of motion, all the parts being soldered together and encased almost as firmly as in the chrysalis of a butterfly. The head and prothorax are suddenly bent forward, the former touching the breast, and the back is curiously flattened. The rove-beetles are, as a general rule, carrion feeders, preying voraciously on decaying animal and vegetable substances ; but some of them are true cannibals, while a few are even parasitic. Indeed they are no doubt more carnivorous than is generally supposed.

Finally, strange as it may seem, the Striped Blister-beetle and the Ash-gray Blister-beetle, which are very injurious to the potato, seem to have the redeeming trait of also preying occasion-

ally on the larva of the Colorado Potato-beetle. It was first difficult to believe or reconcile the statements to this effect, but there have been so many of them that the fact may now be considered as indisputable, and these two blister-beetles may therefore, with propriety, be added to the list of enemies. I by no means advise their protection, however, on this account; for I believe that what little good they accomplish is much more than outweighed by the injury they do us. As authorities for these statements may be quoted, among many others, Abel Proctor, of Jo Daviess county, Ill., and T. D. Plumb, of Madison, Wis.

“When dog eats dog, then comes the tug of war;”

when rogues fall out, honest men come by their own.

Ord. *Hemiptera*.—All the insect enemies of our Potato-beetle so far mentioned destroy it by mastication with their jaws—all of them being possessed of powerful mandibles. The several true bugs, belonging to the Heteropterous division of the Order under consideration, obtain their food on the contrary by suction, piercing their victim with their sharp beak or proboscis. The following species are known to attack our Doryphora :—

1.—The Spined Soldier-bug (*Arma\* spinosa*, Dallas). This is one of the most common and efficient of Doryphora's enemies, occurring in all parts of the country, and seeming to have a decided fondness for our potato-destroyer, especially for the soft larva. It is of an ochre yellow colour. Thrusting forwards his long and stout beak, he sticks it into his victim, and in a short time pumps out all the juices of its body and throws away the empty skin. He belongs to a rather extensive group (*Scutellera* family) of the true bugs (*Heteroptera*), distinguishable from all others by the very large scutel, which in this genus is triangular, and covers nearly half the back. Most of the genera belonging to this group are plant-feeders, but there is a sub-group (*Spissirotres*), to which our cannibal friend belongs, characterised by the robustness of their beaks, and all of these seem to be cannibals. The Spined Soldier-bug may be at once distinguished from all allied bugs, whether plant-feeders or cannibals, by the opaque brown streak at the transparent and glassy tip of its wing-cases.

It has sometimes been reported that the common Squash-bug (*Coreus tristis*, De Geer), preyed upon

\* Belongs to the modern generic subdivision *Podisus*.

the Colorado Potato-beetle; but there can be very little doubt that the Spined Soldier-bug has in these instances been mistaken for it. The colours of the two are somewhat similar, but in the eyes of an entomologist the Squash-bug looks as different from the Spined Soldier-bug as a cow does from a horse!

While treating of the Spined Soldier-bug, it will be well perhaps to state that though, with all true Bugs, its larva and pupa are active, and have the same habits and general form of the mature insect, yet they differ so much in coloration and pattern, that they are scarcely ever properly identified, and have often been sent to me as a new Potato-bug enemy by those who have found them boldly following out their naturally voracious instincts.

The eggs of this Soldier-bug are pretty, little bronze-coloured, caldron-shaped objects, with a convex lid, around which ciliate fifteen or sixteen white spines. They are neatly placed side by side in clusters of a dozen or more upon leaves and other objects, and are so much subject to the attacks of a minute Hymenopterous parasite, that those who undertake to hatch such as are found out-doors will more often get flies than bugs. The

newly hatched bug is ovoid, and shiny black, with some bright crimson about the abdomen. In the full-grown larva, the black still predominates on the thorax, but some four yellowish spots appear, and the abdomen becomes more yellowish, though still tinted with red. In the pupa, which is readily distinguished by the little wing-pads, the ochreous-yellow extends still more, and finally, with the last moult, the black disappears entirely in the perfect insect. Throughout the immature stages the shoulders are rounded, and not pointed, and the antennæ, or feelers, have but four joints instead of five, as in the mature bug, while there are but two visible joints to the feet, or tarsi, instead of three.

We have been taught to admire the muscular power of the lion, which is enabled to grip and toss an animal larger than itself with its powerful neck and jaws; but feats performed by these young Soldier-bugs throw the lion's strength completely into the shade, for they may be often seen running nimbly with a *Doryphora* larva, four or five times their own size, held high in air upon their out-stretched beak.

*The Spined Soldier-bug* by no means confines

himself to Potato-beetle larvæ, but attacks a great number of other insects.

2.—An allied species (*Arma* [*Podisus*] *cynica*, Say), of the same colour as the preceding, but about twice as large, and less common, has the same habit of feeding on *Doryphora*.

3.—The Bordered Soldier-bug (*Stiretrus fimbriatus*, Say). This belongs to the same sub-group, and has the same kind of short, robust beak as the preceding, but unlike that species, it is so conspicuously and prettily marked that it cannot easily be confounded with any other. Its colours are dark olive-green and cream-colour. It is not so common as the preceding species.

4.—The Many-banded Robber (*Harpactor*\* *cinctus*, Fabr.). This species is still more elegantly marked than the preceding. Like the Spined Soldier-bug, this species is common, and inhabits trees more commonly than herbaceous plants; but it belongs to an entirely different group of the true Bugs (*Reduviæ* family), all of which, without exception, are predaceous, and are characterised by a short, robust, curved beak. Its colours are

\* *Milyas*, Stål.



yellow, white, and black, and it may be known by the name of the Many-banded Robber.

5.—The Rapacious Soldier-bug. This bug (*Reduvius raptatorius*, Say), belongs to the very same group as the preceding. It is of a brown colour and easily recognized. It likewise has the same habit.

6.—The Ring-banded Soldier-bug (*Perillus circumcinctus*, Stål), is the fifth member of this useful group. This prettily marked insect is of a rich polished brown colour, with pale yellow. Underneath on the venter there is a large yellow patch containing four black spots quadrangularly arranged, and there is a border of yellow extending around the edge of the whole body. It is a not uncommon species.

7.—The Dotted-legged Plant-bug. This species (*Euchistus punctipes*, Say), is minutely speckled, and of an ochre-yellow colour, and closely resembles the Spined Soldier-bug. The most obvious features whereby to distinguish these two insects are the more flattened form of the Soldier-bug and especially of its quadrate head and its sharp-pointed thorax. This last character is variable in both, so that specimens of the former occur with the thorax

rounded, and of the latter with it more or less pointed; but there are two other structural differences which are always constant, and can always be relied on to distinguish the two insects. If the Spined Soldier-bug be examined underneath, its beak will be found to be quite stout, especially at the base, and between the hind legs at the base of the venter a prominent tooth pointing toward the head will be noticed. This latter feature is entirely absent in the Plant-bug; while the more slender beak of the latter, the average larger size, the black-dotted legs, and the absence of the opaque brown streak at the transparent and glassy tip of the wing-cases (*hemelytra*), combine to distinguish it still further from its more ferocious relative.

The Dotted-legged Plant-bug was once considered a purely vegetable feeder, and its being caught partaking of carnivorous food is somewhat exceptional, though recorded in my 4th Report, and more recently recorded as new, in *Field and Forest* for Oct. 1876. It is, however, an interesting fact, entomologically considered, and shows that the carnivorous is not so widely separated from the herbivorous habit as we are wont to suppose. Indeed an 8th bug called the Large Green Tree-

bug (*Nezara hilaris*, Say), somewhat resembling *Euschistus* in form, but uniformly green in colour, has also been found sucking the juices of our Doryphora larva, though normally it is a plant-feeder.

Ord. *Diptera*.—One of the most efficient, where it occurs, of all the enemies of our Potato-beetle, and the only internal parasite, is what may be called the Doryphora Tachina Parasite (*Lydella doryphoræ*, Riley). It is a two-winged fly belonging to the parasitic family of Tachina-flies (*Tachinidæ*). It bears a very close resemblance, both in colour and size, to the common house-fly, but is readily distinguished from the latter by its extremely brilliant silver-white face. It may be seen throughout the summer months flying swiftly from place to place, and deftly alighting on fence or wall, where, basking in the sun, its silvery face shows to good advantage. As with the rest of the family to which it belongs, the habit of the female is to attach a single egg externally to the body of the Potato-beetle larva. This egg subsequently hatches into a little footless maggot, which burrows into the body of its living victim, and eventually destroys it, but not until it has gone underground in the

usual manner. The victimised larva, instead of becoming a pupa, and eventually a beetle, as it would have done had it not been attacked, begins to shrink as soon as it enters the ground, and gradually dies; while inside its shrivelled skin the parasitic maggot contracts into a hard brown pupa, and in due time issues forth in the shape of the fly which I have described. This fly has been found at times so abundant in western potato fields, that its buzzing resembled the noise made by a swarm of bees, and the *Doryphora* was well-nigh exterminated by its progeny.

In addition there are in this order certain large *Asilus*-flies, and notably the Missouri Bee-killer (*Protocanthus Milberti*, Macq), which pounce upon and suck the vitals out of the *Doryphora* larva. All these large flies are very bloodthirsty—the hawks of the insect-world; and some of them are quite injurious to bees.

Thus, besides one spider and one mite, there are a full two dozen species of true insects, viz.: one wasp, fifteen beetles, six half-wing bugs, and two flies, that have been actually observed by myself and others, preying on the Colorado Potato-beetle. The number has increased from year to

year as the insect widened its range, and there will no doubt yet be many predaceous species added to the list.

#### REMEDIES.

These fall into four different categories. 1st, Encouragement of the natural enemies just referred to; 2nd, Preventive measures; 3rd, Mechanical means of destruction; 4th, The use of poisonous applications to the plant for the same purpose.

##### 1st.—*Encouragement of Natural Enemies.*—

Under this head it is only necessary to draw the reader's attention to those which have been described, and to urge their protection wherever found. More particularly in hunting for the Doryphora eggs early in the season, the farmer should learn to discriminate between them and the similar but invariably smaller eggs of the Ladybirds.

##### 2nd.—*Preventive Measures.*—

Something may be done in this line in the fall by means of heaps or rows of straw, or of the dried potato-haulm, under which some of the beetles will shelter to hibernate, and may be killed in winter. In the spring, some good may be accomplished by adopting the follow-

ing plan: Slice some potatoes, dust the pieces with Paris Green, and drop them about a field early in the season when the beetles come from their winter quarters. They feed upon the slices and of course die. The method can only be safely practised where no domestic animals can get at the baits. Another method is that first employed by Mr. James Rivers, of Cass County, Mich., viz., a mixture of chicken manure and ashes, applied to each hill of potatoes just as the plants are coming through the ground,—the object being to check the cracking and raising of the soil, and thus prevent the beetles from hiding around the young plants at night or during cold weather. The application appears, in addition, to keep the beetles off at the same time that it invigorates the plant.

Col. Fred. Hecker, of Summerfield, Ill., once had a patch of potatoes covered with straw, which had entire immunity from the insect's attack; but it is doubtful whether under the same treatment such immunity could always be relied upon. Careful watch should be kept for the eggs that are first deposited. By stooping the body, they are easily seen on the underside of the leaves when the plants are young. Thorough cultivation by means

of frequent stirring of the soil should be practised. Early varieties in preference to late ones should be planted, because the insects are usually more numerous late in the season than they are during the spring and early summer. The preference should be given to the Peach Blow, Early Rose, and such other varieties as have been found most exempt from attack, and the fields surrounded on the outside by rows of such tender-leaved varieties as the Mercer, Shaker, Pinkeye, and Early Goodrich. The beetles will be attracted to these, and the labour of killing will be facilitated. Above all, the potato field should be isolated as much as possible, either by using land surrounded by timber, or by planting in the centre of a cornfield. It is well also to plant in ground that was not the previous year used for potatoes.

3rd.—*Mechanical Means of Destruction.*—One of the simplest means of destruction is, of course, hand-picking, and when pursued early in the season, it is most effectual. In doing so it is generally the custom to collect the beetles and larvæ in some vessel of water and afterwards destroy them; but it is perhaps preferable to crush them while on the vines, and for this purpose a

very simple pair of pincers, consisting of two pieces of wood, a screw, and two small strips of leather, will be found very useful.

During the summer of 1870 there was a sudden diminution of the numbers of this insect throughout the Mississippi Valley, and it did not increase to any alarming extent during the rest of the season. The disappearance was in many sections so thorough that it is very questionable whether man and natural enemies should alone be credited with the cause. The spring was uncommonly dry and warm, and, so far, was favourable to the increase of the insect; but the summer drought and extreme heat which followed were quite unfavourable to its multiplication. Warm, dry weather in spring is congenial to the growth and well-being of the larvæ, as they swarm upon and devour our vines; but at a later stage of their lives, when they have to enter the earth to undergo their transformations, a great many of them will undoubtedly die, if the earth continues excessively dry and hot. They will, in short, be dried and baked to death. Those who have had large experience in breeding insects, and who understand the importance of coolness, and especially of moisture, in the successful develop-



ment of those which transform under ground, feel perfectly warranted in such an inference, even though no systematic and accurate experiments have been made to test its validity. The extreme heat and dryness of the season furnished a good opportunity to employ the sun-scalding remedy, and it was fully shown that in an intense summer sun, the larvæ and even the beetle will generally die, if knocked from the vines on to the dry and heated ground, especially if the vines have been well hilled. During hot, dry weather, therefore, especially in the more southern latitudes where the insect ranges, this mode of destruction may be employed to advantage ; but it should not be forgotten that some of the full-grown larvæ will doubtless enter the ground, and that the method can only be employed at a season when the insects have done most of their damage.

A cheap, rapid, and effective method, which commends itself to the good sense of every one, is for one person to go along the rows with a short-handled broom, and by quick motions knock all the beetles off, while a second person follows immediately after, dragging by a single horse a heavy bundle of brush, or close-toothed harrows made for

the purpose. Some of the insects will escape being killed, and a few of the younger larvæ may not be knocked off, but the operation is so rapidly performed that it will bear repetition as often as necessary.

As the ravages of *Doryphora* became more and more general and destructive, and the necessity for its extermination became correspondingly urgent, the inventive genius of many farmers and gardeners was exercised in devising implements for its destruction, which would do the work more expeditiously and cheaply than it could be done by hand.

One of the first of these was a 'horse-machine, invented in 1866, by a Mr. Benson, of Muscatine, Iowa. As this machine, or some improvement on it, may prove advantageous where potato growing is carried on extensively, I subjoin his account of it.

The cost of the machine was about thirty dollars. It consists of a frame-work, which moves astride the row of potatoes, on which is mounted longitudinally a reel somewhat like the one on McCormick's old Reaper, which knocks the bugs off the plants into a box on one side. This box is of course open on the side next the row nearly down to the ground, but is some two feet high on the outside and at the ends. The reel works over the inner

edge of the box, and the bugs are whipped off the vines pretty clean; and the most of them are thrown against the higher side of the box, which converges like a hopper over two four-inch longitudinal rollers at the bottom, between which the bugs are passed and crushed. These rollers are some three or four feet long.

Those insects which are perched low down on the plants are frequently knocked on to the ground; but I think they would soon crawl up again; and repeating the operation at intervals would very greatly reduce their numbers, and lessen very much the labour of hand-picking, which I think would be advisable in conjunction with the use of the machine, in order to destroy the eggs and diminish the young brood, which is most destructive to the foliage of the plant.

In 1870 Mr. George Squires, of Montgomery, Ill., built a machine to be drawn by horses, which worked very effectually. It is a modification of the one invented by Mr. Benson, described above, being a simple box, six inches high, with wheels to which brooms are attached to sweep the vines—the wheels circling towards the box.

Mr. Samuel Creighton, of Lithopolis, Ohio, subsequently invented his "Improved Patent Insect Destroyer," which is especially intended for this insect. It is a hand machine of a very simple nature, consisting of a plate with two curved sides

and a handle. In using, it is held in the right hand and placed at one side of the potato hill, with the upper end more or less inclined, according to the size of the plants. In this position the lower branches of the plants will overhang the forward edge of the plate, and the flanges of the sides, which are slightly bent outwards, will embrace the second and third side of the vines, leaving the fourth exposed. The operator then strikes this exposed side, with a light, flat, and broad broom, thus detaching the insects, which fall to the bottom of the trap. Whenever the trap is filled the insects are emptied out through a sliding door, and destroyed in whatever manner the operator sees fit. A good size for this trap is  $2\frac{1}{2}$  feet in height, 15 inches from flange to flange, and 7 inches across the narrow way of the pocket. It should be made of tin, or if of wood, the pocket should be lined with tin: as when kept smooth or moistened with oil or water, the insects cannot easily crawl out, as one goes from hill to hill. This contrivance is but an improvement on the common tin pan, and its principal merit lies in its cheapness and simplicity.

Mr. H. Bowen, of Sheridan, Illinois, thus describes an instrument which he has used with ease

and profit. It is not patented, and commends itself for lightness and simplicity:

Take four wooden barrel hoops and two narrow barrel staves, two and a half inches wide, and two more. For the handle use a hoop of sufficient length to be handy for the person that uses it, open it and fasten it to the staves. All these pieces are to be nailed together with small wrought clinch nails. When this is done the instrument should be nearly in the form of a flour-scoop. The framework is then to be covered by sewing on cotton cloth.

To work it, it is held in one hand, and the mouth is slipped around the hill of potatoes close to the ground. With the other hand the vines are struck a light blow with a *new* broom, and all the bugs are jarred into the cage. After a quantity has been "bagged" they are emptied out and destroyed.


There are several other devices, both patented and non-patented, all having the same object in view. Most of them are too complicated to be very practical, and none that I am acquainted with are superior to the few here referred to.

The great difficulty with all mechanical contrivances of this kind, lies in the fact that they can only be used when the vines are of a considerable size, whereas the enemy must be most persistently fought from the moment the ground parts to give

way to the sprouting tuber, until the plants are a few inches high.

4th.—*Poisonous Applications to the Plant.*—After the beetle had established itself in the more densely populated States, it soon became evident that neither hand-picking nor more wholesale slaughter by means of mechanical contrivances would enable the potato-grower to cope successfully with his enemy. Many farmers preferred to lose their potato crop rather than to expend the amount of time and labour necessary to secure it, and the pest, in consequence, multiplied to an alarming extent. The discovery of a cheap, easily applied and reliable destructive agent became all important, and to this end numerous experiments were made by the writer, in 1869, with various poisonous and acrid substances, among which were lime, ashes, cobalt, white hellebore, cresylic acid, soap, and arsenic. Some of these produced no effect whatever upon the insects, while others in killing the pests killed the potato-vines as well, and were therefore rejected as impracticable. Paris green, as it was first used, without any admixture, was likewise fatal to the vines; but the discovery was soon made that when combined with certain pro-

portions of flour or plaster, and applied while the dew was on, the insects were killed without any deleterious effects being produced upon the plants. This substance has now become THE remedy for the Colorado Potato-beetle, and it is the best yet discovered. Having thoroughly tested it myself, and having seen it extensively used, I can freely say that, when applied judiciously, it is efficient and harmless. If used pure and too abundantly, it will kill the vines as effectually as would the bugs, for it is nothing but arsenite of copper (often called "Scheele's green" by druggists), and contains a varied proportion of arsenious acid, according to its quality—often as much as fifty-nine per cent., according to Brande & Taylor. But when diluted with from 15 to 20, or if the green be absolutely pure, with 25 to 30, times its weight of flour, it causes no injury to the foliage, and just as effectually kills the insects. The varied success attending its use, as reported through our many agricultural papers, must be attributed to the difference in the quality of the drug. The adhesive property of flour—which may be of the most inferior quality—gives it an advantage over ashes, plaster, and slaked lime, although these may have



the advantage of cheapness and are frequently used. The green cannot well be mixed with the other substances, except by the aid of a mill, and it is for this reason that those who mix in large quantities have the advantage.

Paris green is now also used to a considerable extent in liquid suspension, in proportion of one tablespoonful of pure green to a bucketful of water. The liquid has the advantage over the powder, in that there is less danger from injury in its use, and that it can be effectually used at any time of day ; while the powder can be employed to advantage only while the dew is on the plants. It has, however, some disadvantages: 1st, the green is not soluble, for though it quickly gives a green tint to the water when stirred, it soon settles to the bottom, unless kept in suspension by continued stirring or agitation ; 2nd, it settles in spots on the leaves, the natural tendency of the water, in finding its level, being to carry and concentrate it wherever a drop finds rest and evaporates ; 3rd, too much is usually wasted on the ground in the sprinkling. I have, therefore, found it much more convenient, on a small scale, to use the powder, where it can be obtained ready mixed by machinery. Applied



when the dew is on the plants it will adhere more uniformly, and it obviates the necessity of carrying about so much water.

But whether the green be used in water or as a powder, the flour will prove a desirable addition, since it renders the green more adhesive and consequently more serviceable. Some care will be required in using, however, to prevent its forming lumps. The adhesive quality in the liquid may also be obtained by dissolving molasses, dextrine, or gum arabic in the water—the two latter, however, much more expensive than the flour. The green in the form of powder may be shaken over the vines in various manners, and some persons have found an old sleazy sack, such as those used for table salt, to do good service, when attached to the end of a stick. It is most safely applied by the aid of a perforated tin box with a double lid for safety when not in use, and attached to the end of a stick three or four feet long. The least possible dusting suffices, and by taking the handle of the dust-box in the left hand, and then tapping the box with a stick held in the right hand, one can walk rapidly along and regulate the amount sifted.

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In the form of liquid the green may be sprinkled over the vines with a sprinkler or an old broom. This will serve on a small scale, but for large fields various contrivances have been successfully employed to save time and labour.

In 1874 Mr. Frank M. Gray, of Jefferson, Cook county, Ill., sent me a sprinkler which he has constructed for sprinkling two rows at once. It is so simple and yet so useful that a brief description of it will not be out of place here. It consists of a can capable of holding about eight gallons of liquid, and so formed as to rest easy on the back, to which it is fastened, knapsack-fashion, by adjustable straps, which reach over the shoulders and fasten across the breast. To the lower part of the can are attached two rubber tubes, which are connected with two nozzles on sprinklers. The inside of the can has three shelves, which help to keep the mixture stirred. There is a convenient lever at the bottom which presses the tubes and shuts off the outflow at will, and two hooks on the sides near the top on which to hang the tubes when not in use. On the top is a small air-tube and a capped orifice. Two bucketfuls of water are first poured into the can, then three tablespoonfuls of good

green, well mixed with another half-bucketful of water and strained through a funnel-shaped strainer which accompanies the machine, and the use of which prevents the larger particles of the green from getting into the can and clogging up the sprinklers. Five to eight acres a day can readily be sprinkled by one man using the can, and from one to one and a half pound of good green, according to the size of the plants, will suffice to the acre. Two lengths of nozzles are furnished, one for use when the plants are small, the other when they are larger. The can should be filled on the ground and then raised on a bench or barrel, from which it is easily attached to the back. The walking serves to keep the green well shaken, and the flow of the liquid is regulated at will by the pressure of the fingers on the tubes at their junction with the metallic nozzles. When not in use, the tubes should be removed, the can emptied, and laid on its back. I can testify to the ease and efficiency with which this little machine may be used.

An excellent Spray Machine has been invented by Mr. W. P. Peck, of West Grove, Pa., consisting of a tank, strapped knapsack-fashion on the shoulders, and connected by rubber tubes with a

pair of bellows, strapped to the waist, turned by a crank, and connected with a movable nozzle. I have used it with good results, and know of no instrument that better answers the purpose, or more effectually economizes material. This atomizer can of course be used to distribute other liquids than Paris green water, and to protect other plants than potatoes; but for use in the potato field it answers an admirable purpose. The tank holds three gallons, and there is a simple device at the bottom which, by the motion of walking, keeps the liquid in agitation and prevents the green from settling. The liquid issues in a fine spray and with considerable force. The very general use of Paris green as an insecticide had the effect at first to raise the price of the drug to an exorbitant figure, and in many places the demand largely exceeded the supply. The impetus given to its manufacture, however, soon reduced it to a reasonable price again, and of late years the cost of its use to protect a potato-field, even where the insect has been very abundant, has averaged only from \$3 to \$5 per acre, according to the number of applications.

In addition to Paris green, a great number of

may induce some to try it who are prejudiced against *Paris Green*.

ASHES and AIR-SLAKED LIME, we found, had been extensively used by many of the farmers on the frontier districts, but, so far as we could see or learn, without any perceptible results.

Decoctions of Elder leaves, Dog-fennel, the roots of the Mandrake or May Apple (*Podophyllum peltatum*), black-pepper, ashes, lime, and a variety of other applications have been recommended. Many of the proposed remedies are simply ridiculous, while some are partially effective. Both lime and urine or uric acid have been used with good effect, but do not compare to Paris green.

A correspondent of the *Prairie Farmer*, for July 3, 1875, in whose signature—"T. of Iowa"—I recognize an old friend and intelligent observer, gives the following experience :

I have had quite as good success in using the ingredients from which the green is made, as from the finished article, bought in paint and drug shops at 50 cents a pound, especially when the local demand is so great that it cannot be bought at all. The following directions for making it are taken from Brande's Chemistry : Dissolve two pounds of sulphate of copper, blue vitriol (costing 20 cents per lb., or 40 cents), in a gallon of hot water, *keeping it in a stone jar*. Dissolve in another large jar,

one pound of white arsenic (costing 10 cents), and two pounds of saleratus or pearl ash (cost 20 cents), in forty-four pounds of hot water, stirring well, until thoroughly dissolved. These articles, costing 75 cents, will make about five pounds of Paris green, costing \$2.50. I usually keep them in solution and mix in the proper proportions, one part of the first to five of the latter, as they are needed. The green immediately begins to precipitate in a fine powder, and is much more convenient for use, in solution, than the dry article sold in the shops.

Before leaving this subject of poisonous applications, it may be well to say a few words about two other compounds that have been strongly recommended and advertised as such. One of these is advertised as "Potato Pest Poison," by the Lodi Chemical Works of Lodi, N. J. It is put up in pound packages, which are sold at \$1 each, with directions to dissolve four ounces in two quarts of hot water, then pour into a barrel containing thirty gallons of cold water, and use on the vines in as fine a spray as possible. Analysis shows it to be composed of one part of pure salt and one part of arsenic (arsenate of soda), and it has the general colour and appearance of common salt. I had this poison tested in a field of late potatoes, which had been badly infested during the summer, but of which about half the vines had been saved by

pretty constant hand-picking. These were at the time fairly covered with the insect in the egg, larva, and beetle states. Five rows were treated with the poison, both according to directions, and by finely sprinkling the dry powder over the vines. As soon as the powder touched the larvæ, they writhed and became restless, as with pain, the powder dissolved and formed a translucent coating upon them, and in about three hours they began to die. The beetles were not so easily affected, though they, too, were in time killed by it. Used as directed, it destroys, but hardly as efficiently as the ordinary Paris green mixture. A pound of Paris green, costing much less than a pound of the Lodi poison, will go nearly as far in protecting a field of potatoes, and I cannot see any advantage to the farmer from the employment of a patent poisonous compound, of the nature of which he is ignorant, when a cheaper one is at hand. The colour of the Lodi poison is also very objectionable, as there is much more danger in the use of poisons when their colour renders them undistinguishable from ordinary salt. The second is a patent "Pest Poison," gotten up by the Kearney Chemical Works, N. Y., and extensively advertised for this particular insect. It

is a prototype of the preceding, consisting of arseniate of sodium and common salt, faintly coloured with rosaniline, and it acts in a similar manner. It is put up in a  $\frac{1}{2}$  lb. package, for 50c., which is to be dissolved in 60 gallons of water, and all that has been said of the Lodi poison is true of it.

#### THE USE OF PARIS GREEN.

As this mineral has now come into general use for the Colorado Potato-beetle, and likewise for the Cotton Worm and various other insects; and as it is a virulent poison, the question as to its safety for the purpose here recommended is a very important one. It was my lot to be largely instrumental in causing its now general use for the two insects mentioned, and the position which I took from the first has been justified by the facts, which are herewith presented, and which will serve to dissipate much misapprehension.

*Past Experience.*—In the early history of the use of this mineral as an insecticide, most persons, myself included, were loth, on theoretical grounds, to recommend its general use; and I have ever insisted that the many other mechanical and preventive measures, which, if persistently employed,



are sufficient to defeat the foe, should be resorted to in preference. But the more diluted form and improved methods nowadays employed in using the poison, render it a much safer remedy than it was a few years back; and no one should fail to take into account that during the past seven or eight years, millions of bushels of potatoes have been raised, the leaves of which have been most thoroughly sprinkled with the Paris green mixture, without any injurious effect to the tuber, or to persons using potatoes raised in this manner. Indeed, scarcely any potatoes have been raised in the Middle States during these years without its use; yet I have to learn of the first authentic case of poisoning or injury whatever, except through carelessness and exposure to its direct influence. So far as experience goes, therefore, there is nothing to fear from the judicious use of the mineral. Let us then consider, from the best authority, what are the effects of its use as at present recommended: First, on the plant itself; second, on the soil; third, on man, indirectly, either through the soil or through the plant.

*Its Influence on the Plant.*—Practically the effect of sprinkling a plant with Paris green, will depend

very much on the amount used, and on the character of the plant treated. Thus, from experiments which I made in 1872, a thorough coating of a mixture of one part of green to fifteen of flour, while injuring some of the leaves of peas, clover, and sassafras, had no injurious effect on young oaks, maples, and hickories, or on cabbage and strawberries; while the fact has long been known that when used too strong and copiously it destroys potato vines. It is for this reason that the experiments that were made in 1874 on beets, by a committee appointed by the Potomac Fruit Growers' Society, are of little value, as against the universal experience of the farmers of the Mississippi Valley. The mixture used by the committee, and which they call "highly diluted," consisted of one part of green with but six of the dilutent, instead of from twenty-five to thirty parts of the latter; and it is no wonder that, as reported by the committee, the vitality of the plant was seriously impaired. There can be no question, therefore, about the injurious effect of the green upon potato vines, when it is used pure or but slightly diluted; yet in this case, since it is the office of the leaves to expire rather than inspire, we cannot say that the plant is

injured, or killed by absorption, any more than if it were killed by hot water, which, according to the degree to which it is heated, or the copiousness of the application, may either be used with impunity or with fatal effects. Indeed, judging from my own experience, I very much incline to believe that future careful experiments will show that injury to the leaf by the application of this compound arises more often from the stoppage of the stomata, which is effected as much by the dilutant as by the arsenite itself. So much for the influence of the poison when coming in contact with the plant above ground. The question as to how it affects the plant below ground, through the roots, may be considered in connection with—

*Its Influence on the Soil.*—As Prof. S. W. Johnson, in an able review of the subject, stated two years ago: \* “One pound of pure Paris green contains about ten ounces of white arsenic, and about four ounces of copper;” or, to state it in the usual way, Schweinfurt, or *pure* Paris green, contains fifty-eight per cent. of arsenious acid. One pound of the green uniformly spread over an acre of soil, would amount to sixteen-hundredths of a grain

\* *New York Tribune*, December 16, 1874.

per square foot, or nine-hundredths of a grain of arsenious acid. If uniformly mixed with the soil to the depth of a foot, it would, of course, be the same to the cubic foot. In actual practice, even this amount does not reach the soil direct, or in an unchanged form, since much of it is acted upon by the digestive organs of the fated insects. It is safe to say that even if the green retained for all time its poisonous power and purity in the soil, this mere fractional part of a grain might be added annually for half a century without any serious effects to the plants. In reality, however, there is no reason to believe that it does so remain. Of the few experiments on record which bear on this point, those made by Prof. R. C. Kedzie, of the Michigan Agricultural College, in 1872, are most interesting and instructive. In a paper read before the Natural History Society of the College, he proved, from these experiments, that where water was charged with carbonic acid or ammonia, a certain portion of the green was dissolved, but was quickly converted into an insoluble and harmless precipitate with the oxide of iron which exists very generally in soils. Fleck has shown (*Zeitschrift für Biologie*, Bd. viii, s. 455, 1872), that arsenious acid in con-

tact with moist organic substances, especially starch sizing, forms arseniuretted hydrogen, which diffuses in the air, and it is more than probable that the green used in our fields will lose its poisonous power, and disappear in these and other ways. The question as to how the plant is affected by the poison through the soil is, therefore, partly answered by the above facts. Water is both the universal solvent and the vehicle by which all plants appropriate their nourishment; but in this instance its solvent and carrying power is for the most part neutralized by the oxide of iron in the soil; and though some experiments by Dr. E. W. Davy, and quoted by Prof. Johnson in the article already cited, would indicate that, under certain circumstances, some of the arsenious acid may be taken up by plants before passing into the insoluble combination; yet the quantity is evidently very slight.

Moreover, all doubt as to the danger to the tuber, to the soil, or to man, indirectly, was set at rest by a further series of thorough experiments made by Prof. Kedzie in 1875, from which he concludes: 1st, Paris green that has been four months in the soil no longer remains as such, but has

passed in some less soluble state, and is unaffected by the ordinary solvents of the soil. 2nd, When applied in small quantities, such as alone are necessary in destroying injurious insects, it does not affect the health of the plant. 3rd, The power of the soil to hold arsenious acid and arsenites in insoluble form will prevent water from becoming poisoned, unless the green is used in excess of any requirement as an insecticide.

These experiments of Prof. Kedzie's accord, so far as they refer to the influence of Paris green on man through the plants, with others by Prof. McMurtrie, of the Department of Agriculture, which showed that even where the green was applied to the soil in such quantities as to cause the wilting or death of the plants, the most rigorous chemical analysis could detect no trace of arsenic in the composition of the plants themselves.

Some persons have imagined that the soggy and watery potatoes that have been so common of late years are due to the influence of this poison ; but this idea is proved to be erroneous by the fact that such imperfect potatoes are not confined to the districts where Paris green has been used. Indeed, they are much more likely due to the injury and

defoliation of the plant by the insect ; for no plant can mature a healthy tuber when its leaf system is so seriously impaired by the constant gnawings of insects. Finally, we must not forget that both arsenic and copper are widely distributed throughout the inorganic world\* and are found naturally in many plants ; and so far from injuring plants, in minute quantities, arsenic occurs in the best superphosphates and the volcanic soil around Naples, which, like all volcanic soils, contains an

\* Prof. Johnson (*loc. cit.*) writes :—"The wide distribution of both arsenic and copper is well known to mineralogists and chemists. These metals are dissolved in the waters of many famous mineral springs, as those of Vichy and Wiesbaden. Prof. Hardin found in the Rockbridge Alum Springs of Virginia, arsenic, antimony, lead, copper, zinc, cobalt, nickel, manganese, and iron. The arsenic, however, was present in exceedingly minute quantity. Even river water, as that of the Nile, contains an appreciable quantity of arsenic. Dr. Will, the successor of Liebig, at Giessen, proved the existence of five poisonous metals in the water of the celebrated mineral springs of Rippoldsau, in Baden. In the Joseph's Spring he found to 10,000,000 parts of water, arsenic (white), 6 parts ; tin oxide, 1-4 part ; antimony oxide, 1-6 part ; lead oxide, 1-4 part ; copper oxide, 1 part. Arsenic and copper have been found in a multitude of iron ores, in the sediments of chalybeate springs, in clays, marls, and cultivated soils. But we do not hear that the arsenic thus widely distributed in waters and soils ever accumulates in plant or animal to a deleterious extent."

unusual amount of it, has the reputation of being a specific against fungus diseases in plants. A certain quantity may therefore be beneficial to plants, as it appears to be to animals, since horses fed on a grain or two a day are said to thrive and grow fat.

*Its Influence on Man indirectly through the Soil or through the Plant.*—The green as now used could not well collect in sufficient quantities to be directly deleterious to man in the field in any imaginary way, and this statement is borne out by Prof. Kedzie's experiments; while its injury through the plant is, I think, out of the question; for the plant could not absorb enough without being killed. The idea that the earth is being sown with death by those who fight the Colorado Potato-beetle with this mineral, may, therefore, be dismissed as a pure phantasmagoria.

In conclusion, while no one denies the danger attending the careless use of Paris green, and all who have recommended its use have not hesitated to caution against such carelessness, a careful inquiry into the facts from the experimental side bears out the results of a long and extensive experience among the farmers of the country—viz.:



that there is no present or future danger from its judicious use, in the diluted form, whether as liquid or powder, in which it is now universally recommended. It is in this as in so many other things, a proper use of the poison has proved, and will prove in future, a great blessing to the country, where its abuse can only be followed by evil consequences. Poison is only a relative term, and that which is most virulent in large quantities is oftentimes harmless or even beneficial to animal economy in smaller amounts. The farmers will look forward with intense interest to the work of the committee appointed by the National Academy, or of any national commission appointed to investigate the subject, and will hail with joy and gratitude any less dangerous remedy that will prove as effectual; but until that is discovered, they will continue to use that which has saved them so much labour and given so much satisfaction. I would therefore say to those agriculturists of the East who are in any way alarmed by what has been written on this subject, and who hesitate to use the Paris green mixture—profit by the experience of your more western brethren, and do not allow the voracious *Doryphora* to de-

stroy your potatoes when so simple and cheap a remedy is at hand.

In case of direct poisoning from carelessness or whatever cause, it will be well to state here that the antidote for Paris green poison is hydrated sesquioxide of iron. Nearly every druggist keeps it always on hand. If it cannot be bought, it may be prepared thus : Dissolve copperas in hot water, keep warm, and add nitric acid until the solution becomes yellow ; then pour in ammonia water—common hartshorn—or a solution of carbonate of ammonia, until a brown precipitate falls. Keep this precipitate moist and in a tightly corked bottle. A few spoonfuls taken soon after even a bad case of poisoning with Paris green or arsenic is a perfect remedy.

#### BOGUS EXPERIMENTS.

It was once reported to me that a neighbour had succeeded in driving away all his potato bugs by strewing elder branches among the vines. I went to examine the field and found my friend enthusiastic over his discovery ; and indeed though the vines were nearly devoured, there were but a few full-grown larvæ to be found. But, as he could

not tell us what had become of the "slugs," I undertook to show him where they had gone, and after digging a few moments with a trowel, unearthed dozens of them, the majority in the pupa, but a few yet in the larva state. He had, in fact, been misled by appearances, for want of better knowledge of his enemy. The larvæ as they acquired their growth suddenly became so destructive, that to save his vines he was obliged to try some means of killing them, and as an experiment he tried the elder. The larvæ were just ready to disappear of their own accord, and as the great bulk of them did really disappear in two or three days after the application, the apparently logical inference was made that they had been driven away by the smell of the elder.

How many of the published remedies that flood the country owe their origin to just such defective proof.

#### ALARM ABOUT THE INSECT ABROAD.

In 1871, speaking of the eastward march of this insect, I wrote as follows: "Indeed, it is quite possible that even the broad Atlantic may not stay its course; but that when once the beetles swarm

in the streets of New York as they did in those of St. Louis last spring, some female, loaded with fertile eggs, and hidden in the nooks and crannies of some vessel, may be safely borne over to the land of 'murphies,' where she might easily found a colony which would soon spread consternation into other potato-growing countries to the eastward. In giving, through Sir Walter Raleigh, the precious tuber to Europe, America conferred upon the Old World an everlasting boon. She may yet unwittingly be the means of bequeathing as great a bane, by sending across the ocean the deadliest enemy of that tuber! At all events, it behoves our European neighbours to be on the look-out, and to prevent, if possible, any such catastrophe."

In December, 1872, Col. Fred. Hecker, of Summerfield, Illinois, the well-known and enthusiastic political agitator and tribune, sent to the *Gartenlaube* (Heft 3, 1873), an article on this insect. The article was a condensation, and in some parts a literal translation from my Reports, my figures being copied to illustrate it. It was afterwards re-translated and the illustrations re-copied (and accuracy is not apt to increase with these processes, and certainly did not in these instances) for several

English journals, over the signature "*Fr. H., State of Illinois.*" Some of the articles in the English periodicals on this "new enemy of the potato" close with the advice that "in the importation of seed of American potatoes, which is now carried on to a very large extent, the utmost caution should be exercised to prevent the introduction of the beetle to this country."

Indeed, Mr. J. Algernon Clarke, Secretary of the Central Chamber of Agriculture, on the 10th of February, 1874, addressed a letter to Mr. Gladstone, calling his attention to the imminent risk to which the United Kingdom, especially Ireland, is exposed, and went so far as to suggest that the importation of potatoes from the United States and British America should at once be prohibited.

In 1874 the governments of Belgium, France, Switzerland, and Germany prohibited the importation of American potatoes, and Italy, the Netherlands, and Great Britain, which had been urgently solicited to follow their example, began seriously inquiring into the necessities of the case.

The British government was naturally slow to take such stringent steps, which would more deeply *affect it* than the other nations mentioned, since

Great Britain does the larger trade in American potatoes. In reply to Mr. Herbert, M.P. for Kerry, who asked the Chief Secretary for Ireland whether her Majesty's government had taken any steps to prevent the introduction of the insect, Sir M. M. Beach sought to abate fear, rather underrated the danger, and wisely concluded that any interference with the trade should first have the most careful consideration. Those who had watched the insect's gradual spread during the past seventeen or eighteen years, from its native Rocky Mountain Home to the Atlantic, and had seen how the lakes, instead of hindering its march into Canada, really accelerated that march by affording carriage on vessels, rafters, and other floating objects, could have no doubt that there was cause for the danger felt by our transatlantic friends.

Yet the opinion had been repeatedly expressed by the writer—and very generally coincided in by all who had any familiarity with the insect's economy—that when it made its advent into Europe it would most likely be carried in the perfect beetle state on some vessel plying between the two continents. For while the beetle, especially in the non-growing season, will live for


months without food, the larva would perish in a few days without fresh potato tops, and would, I believe, starve to death in the midst of a barrel of potatoes, even if it could get there without being crushed; for while it so voraciously devours the leaves, it will not touch the tubers. The eggs, which are quite soft, and easily crushed, could, of course, only be carried over on the haulm or on the living plant; and while there is a bare possibility of the insect's transmission in this way, there is little probability of it, since the plants are not objects of commercial exchange, and the haulm, on account of its liability to rot, is not, so far as I can learn, used to any extent in packing. Besides, potatoes are mostly exported during that part of the year when there are neither eggs, larvæ, nor potato vines in existence in the United States. There is only one other possible way of transmission, and that is in sufficiently large lumps of earth, either as larva, pupa, or beetle. Now, if the American dealers be required to carefully avoid the use of the haulm or shaw, and to ship none but clean potatoes, as free as possible from earth, the insect's transmission among the tubers will be rendered impossible; and when such precautions

are so easily taken there can be no advantage in the absolute prohibition of the traffic in American potatoes. As well prohibit traffic in a dozen other commodities, in many of which the insect is as likely to be taken over, as in potatoes, and in some of which it is even more likely to be transported. The course recently adopted by the German government, in accordance with the suggestion made in my 6th Report, is much more rational, and will prove a much better safeguard: It is to furnish vessels plying between the two countries with cards giving illustrated descriptions of the insect in all stages, with the request that passengers and crew destroy any stray specimens that may be found. England and Ireland, together with the other European governments, should co-operate with Germany in this plan, and have such a card posted in the warehouses of seaport towns, and the meeting rooms of agricultural societies; and a possible evil will be much more likely avoided.

While some Europeans have thus been unduly alarmed, and inclined to take proscriptive measures to prevent the insect's introduction, others have ridiculed the idea that the insect could get to Europe, one of them declaring that there is no



more danger of the insect's chance transportation than of that of our rattlesnake. Considering that half the weeds of American agriculture, and a large proportion of her worst insect pests, including two beetles—viz.: the Asparagus Beetle (*Crioceris asparagi*), and the Elm Leaf-beetle (*Galeruca calmarimensis*),—in the very same family as our Doryphora, have been imported among us from Europe, there would seem poor foundation for such argument. Moreover, a number of other insects—among them some beetles—of less importance, may be included in the number of importations; and the Rape Butterfly (*Pieris rapæ*), whose progress westward has been simultaneous with the Doryphora's eastward, and whose importation dates back but a few years, gives proof of the fact that insects more delicate and with fewer chances of transport than Doryphora, may succeed in getting alive from one country to the other, and in gaining a foothold in the new home. Indeed, the reported occurrence last summer of a living beetle in the Bremen docks, in a cargo just from New York, is the best evidence; it effectually sets at rest the arguments alluded to, and bears out the views I have on several occasions expressed as to



the possibility of the beetles being carried over in vessels.

It is argued by others that on the continent of Europe our *Doryphora* would not thrive if introduced, and in a recent letter received from M. Oswald de Kerchove, of Gand, Belgium, author of an interesting pamphlet on the insect,\* that gentleman says: "I do not think that the *Doryphora*, awakened by our early warm weather, could resist the effects of the late cold which we are apt to have in these European countries." The idea that the climate of North America is less extreme than that of Europe is rather novel to us of the cisatlantic; and from a sufficiently long residence in England, France, and Germany, I am decidedly of the opinion that they delude themselves who suppose that *Doryphora* could not thrive in the greater part of Europe; and that to abandon all precautionary measures against its introduction on such grounds would be the height of folly. An insect which has spread from the high table-lands of the Rocky Mountains across the Mississippi Valley to the Atlantic, and that flourishes alike in the States of Minnesota, Wisconsin, Upper Canada, and Maine,

\* "L'Ennemi de la Pomme de Terre," etc., Bruxelles, 1875.

and in Maryland, Virginia, and Texas—in fact, wherever the potato succeeds—will not likely be discomfited in the potato-growing districts of Europe.

The more serious and weighty reasons against the possibility of acclimatization, have been urged by H. W. Bates, F.L.S., in a Memoir, published in 1875, in the Journal of the Royal Agricultural Society of England (Vol. XI., Part 2). He argues firstly, that no American beetle has been acclimated in Europe, though several European species are known to have been in America; secondly, that the group to which *Doryphora* belongs is not represented in Europe, and is remarkably restricted to elevated plateaux in the interior of this continent, and range toward the tropics rather than toward the north; thirdly, that the insect has not passed west of the dividing ridge of the Rocky Mountains, or got foothold on the Pacific coast, which in climate more nearly resembles Western Europe.

Mr. Bates lays some stress on the fact that few American plants and insects have been acclimated in Europe, citing only the Common Water Weed (*Anacharis Canadensis*), which has spread through

their ponds and canals, and the Grape Phylloxera, which has done so much injury to French vineyards. He also says that no American beetle has become acclimated. While it is true that we have received many more species than we have given, enough more of our insects and plants have established themselves there to weaken the force of the objection. The Horse Weed (*Erigeron Canadense*), and the Grape Mildew (*Oidium Tuckeri*), may be added to the plants; our common White Ant (*Termes flavipes*) has done much damage in some parts of Germany; the Woolly Aphis, or American Blight (*Eriosoma pyri*), is quite a pest in England and on the Continent; a minute yellow ant (*Myrmica molesta*), which so annoys our housekeepers, has, according to Fr. Smith, been naturalized, and is very troublesome in England; while at least two of our beetles, viz., the Pea Weevil (*Bruchus pisi*), and the American Meal Worm (*Tenebrio obscurus*), have been naturalized in Europe—the former doing some damage in S. France; the latter being quite widespread and now sent back in about equal numbers with the European Meal Worm (*Tenebrio molitor*), by those who make a business of rearing the worms for bird fanciers.

There is some force in all these arguments, but Mr. Bates does not sufficiently appreciate the exceptional adaptive and migrating powers which the species has exhibited. There are hundreds of N. American insects—and some of the most injurious too—which no one fears will ever reach Europe or establish themselves there, because they are restricted, and have for years been restricted, to certain geographical areas. They have exhibited no especial powers of adaptation to new conditions. But our Potato-beetle forms one of those exceptional cases mentioned in the introduction. We mark and note the exceptional vitality though we cannot give a reason for it. Why has *Doryphora 10-lineata* overrun the country and become such a pest while its scarcely distinguishable congener, *Doryphora juncta*, feeding on the same genus of plants, has proved incapable of that adaptation, and remained harmless? Whatever the reason, the fact weakens the force of all generalizations based on geographical distribution. The reasons why the species has not passed west of the Rocky Mountains, find, also, their best explanation in the facts already mentioned in considering the causes which limit its spread.

The possibility of its importation alive is now established. I must think, with the facts before me, that the possibility of its acclimatization is equally great, especially in South Europe. That it would also hold its own in England and Ireland I have not much doubt. It will rather enjoy the more temperate climate; for while it thrives best during comparatively dry seasons, both excessive heat and drouth, as well as excessive wet, are prejudicial to it. Let us hope that it never will become established in Europe, but that a sufficient knowledge of it will be disseminated there to cause the speedy detection and extermination of the few that may from time to time be carried over. Let the Europeans not neglect precautionary watchfulness, however, by virtue of the arguments of those who believe that the insect could not stand their climate—lest they some day learn to their sorrow that they have needlessly underrated our *Doryphora's* toughness of constitution.

## NOMENCLATURE.

The insect was first popularly designated as the "Ten-striped Spearman," which is a translation of its technical name. That term has, however, been

superseded by the name employed in this work, not because it was numerous in Colorado, but because it was first found there by entomologists long before it had advanced to any of the States to the East. There are hundreds of insects that in like manner take their name from some particular district where first discovered, though they often afterwards prove to be far more common in other districts.

Of course the American reader need not be informed of the fact that the insect has been universally known, since it attained popular notoriety, by the scientific name of *Doryphora 10-lineata*, Say. American coleopterists have from the first been fully aware that it differed from the typical genus *Doryphora*, in lacking the point produced on the mesosternum (middle of breast), which is characteristic of that genus as defined by its founder, Olivier. Yet as this character is of secondary importance, and by no means of generic value, in many other families of Coleoptera, and as our insect in other characters, and especially in the short and transverse form of the maxillary palpi, approaches nearer to the genus *Doryphora* than to any other genus of the sub-family (*Chrysomelides*)

the father of American Entomology, Thomas Say, described it under that genus. Subsequent American authorities, including Dr. Le Conte, have followed this enlarged definition of the genus *Doryphora*, considering the palpi of much more value than the sternal characters; and Say's name has consequently been universally adopted in this country both by popular and technical writers. The genus *Chrysomela* of Linnæus has been made the basis of several minor divisions, which are considered to be of generic value or not, according to the opinions of different systematists. Thus Melsheimer in his catalogue of N. A. Coleoptera (1853) refers our Potato-beetle to the genus *Polygramma*, erected by the French entomologist Chevrolat, upon unimportant colorational characters. Subsequently, the Swedish entomologist, Stål, in a monograph of the American Chrysomelides,\* erected the genus *Myocorina*† on the slightly compressed form of the antennal club, for our Potato-beetle, and several other species from Texas and Mexico, while still later *Leptinotarsa*‡ was proposed by the same

\* Trans. Swedish Academy, 1858, p. 316.

† *Myocoryna* was already used by Déjean in the same family.

‡ An examination which I was permitted to make in 1875 of



author. Until some yet distant day, when the science of entomology shall be perfected, there will be a constant chopping and changing in generic nomenclature (much of it of questionable warrant or advantage), and it is oftentimes preferable, especially in popular works, to anchor to the more comprehensive and better known generic terms, instead of confounding the reader by the more recent changes. There is nothing to prevent any author from erecting new genera, but whether a proposed genus is in the end by common consent adopted or not will depend on the value of the characters on which it is founded. Our best authorities ignore the more recent divisions, and

the admirable and extensive collection of Chrysomelidæ belonging to Mr. H. W. Bates, of London, shows that the tibial groove on which Stål founds his new genus *Leptinotarsa*, to which our Potato-beetle is referred, and under which it is published in Gemminger and Harold's Catalogue, is really of no generic value. Several genuine Doryphoræ with the sternal spine fully developed have it in varying degree, and in *concatenata*, (Fabr.) it is even more conspicuous than in *10-lineata*. I fully agree with Dr. Le Conte, that if any character has value in separating *10-lineata*, it is the form of the palpi which ally it more to *Doryphora* than to *Chrysomela*, and make of it, with a few others, a natural group in that genus, distinguished by peculiar coloration and want of development of the sternal spine.

Le Conte writes me, "Let us set our faces against the adoption of the multitude of genera, which even the founders fail to sustain. \* \* \* Let *Polygramma*, *Leptinotarsa*, *Myocoryna*, &c., never be mentioned amongst us." Thence, if we write *Chrysomela* 10-lineata (Say), with Crotch, in his list of N. A. Coleoptera (1873), we indicate that in our opinion the later divisions into which that genus has been broken up, and which would include this species, are not based on sufficiently important and distinctive characters; if we write *Doryphora* 10-lineata, Say, we express our belief in the generic value of the palpal characters. In either event no confusion will ensue providing the authority for the species is given, and the American entomologist does no violence either to good sense or propriety by designating the insect as it was first described, i. e., *Doryphora* 10-lineata. It is because of the present unsettled condition of entomological nomenclature that the custom yet prevails of attaching the abbreviated authority to the names of insects, as the only sure way to express our meaning, and obviate all confusion as to the species intended.

## THE BOGUS COLORADO POTATO-BEETLE.

(*Doryphora juncta*, Germar).

It was at one time quite generally believed that the Colorado Potato-beetle had always existed in the lower Mississippi Valley, for the simple reason that a similar species, the Bogus Colorado Potato-beetle (*Doryphora juncta*, Germar), was confounded with it. This species has existed in the South and South-west, feeding upon the Horsenettle (*Solanum Carolinense*) a plant which is exceedingly abundant in some sections of the West. It has never yet been known to attack the cultivated potato, and in all likelihood never will do so; for as it has existed in the midst of the potato for upwards of a century without ever having been known to attack the plant, it is not at all probable that it will do so at any future time.

This insect so closely resembles *Doryphora 10-lineata* that even a practised entomologist would at first sight be apt to confound the two; it will therefore be worth while to briefly point out the minute but invariable characteristics which distinguish them both in the larval and perfect states.

I first discovered the larva of *juncta*, and reared the beetle from it in 1864, at Columbus, Ky.

The eggs of *10-lineata* are of a translucent orange-red colour, while those of *juncta* are whitish, with a faint tinge of flesh-colour, and still more translucent. The newly hatched larvæ of the former are of a dark Venetian red, and they become lighter as they grow older, while the newly hatched larvæ of the latter have the body as light as the full-grown individuals.\*

In the full-grown larva of *10-lineata* the head is black, the first joint behind the head is pale and edged with black behind only; there is a double row of black spots along the side of the body, and the legs are black, the ground-colour of the body being of a Venetian red. In the full-grown larva

\* It is an interesting fact, that, as I have been able to ascertain by rearing *juncta* from the egg, its newly hatched larva, instead of having the light yellow head and the single row of spots of the mature individuals, has a brown head and two rows of spots, the lower being less distinct than the upper row, and placed exactly in the same position as the lower row on the mature larvæ of *10-lineata*. This is a very pretty exemplification of a very general law which has a significant evolutionary bearing, that all the species of a genus resemble each other more and more as we go back to the beginning of individual life,

of *juncta*, on the contrary, the head is of a pale colour, the first joint behind the head reddish-brown and edged all round with black; there is but a single row of black spots along the side of the body, and the legs are pale, while the ground colour of the body is of a pale cream, tinged with pink or flesh colour. Such are the distinguishing characteristics of the two larvæ; but it is an interesting fact that these characters are not always constant, and that the larvæ of *10-lineata*, especially when they feed upon the Horsenettle, are sometimes almost as pale as *juncta*, and have the lower row of black spots more or less obsolete. The pupa of *juncta* is also the palest.

Now let us see what are the differences in the perfect beetle state of these two insects, which are very minute. It will be found that in the true Colorado beetle the boundary of each dark stripe on the wing-cases, especially toward the middle, is studded with confused and irregular punctations, partly inside and partly outside the edge of the dark stripe; that it is the third and fourth dark stripes, counting from the outside, that are united behind; and that in the leg both the knees and the feet are black. In the other, on the contrary, the

dark stripes are accurately edged by a single regular row of punctations placed in a groove (*stria*) ; it is the second and third stripes—not the third and fourth—counting from the outside, that are united behind, the space between them being almost always brown : and the leg is entirely pale, except a black spot on the middle of the front of the thigh.

The spots on the thorax, in either of the above two species, are normally eighteen in number, arranged in the same very peculiar pattern ; and precisely the same variations in this complicated pattern occur in either species.

THE END.



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